ATTENTION DEFICIT HYPERACTIVITY DISORDER AND PERFORMANCE ON A MEASURE OF SUSTAINED ATTENTION

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"I certify that the substance of this thesis has not already been sumbitted for any degree and is not being currently submitted for any other degree.

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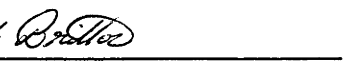
Signed 

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Abstract

The main aim of the present study was to assess ADHD children on tasks requiring sustained attention. It was hypothesised that ADHD subjects would demonstrate unique deficits in their ability to focus and maintain attention relative to controls and independent of their age, intelligence and comorbid Conduct Disorder. Information processing and stimulation models of ADHD were tested to determine and evaluate the effects of increased task complexity and time on vigilance performance.

Sixteen ADHD subjects and 32 controls aged between seven and 12 years (inclusive), matched for age and IQ were compared on both simple (simultaneous) and complex (successive) vigilance tasks. These tasks were based on the Seidel Continuous Attention Test (Seidel & Joschko, 1990) but extended to 20 minutes in time with changes to reduce the priming effects inherent in the successive task. ADHD diagnosis was determined on the DSM-IV criteria using the ADHD Rating Scale and Child Behaviour Checklist profile.

Results found significant decrements in performance on most measures as complexity and time increased for both groups. ADHD subjects were not significantly different from Controls on performance measures across time and/or task. Conduct Disorder rather than ADHD was the best predictor of performance after adjusting for age and IQ. These findings failed to support the central hypotheses of this study and raised questions regarding the validity of the DSM-IV criteria for ADHD and the utility of Continuous Performance Tasks as a measure of sustained attention.

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Table of Contents

Appendices

List of Tables

CHAPTER 1: Introduction

1.1. What is Attention Deficit Hyperactivity Disorder.

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most commonly diagnosed neurocognitive and behavioural disorders in children (Shaywitz & Shaywitz, 1989; Geuvremont & Barkley, 1991). The use of stimulant medication in children in Australia with hyperactivity (and ADHD) has increased by roughly double in two years and continues to increase. In 1992, 8,453 children were treated in NSW with either Dexamphetamine or Methylphenidate (MPH)(Levy, 1993). This represents 0.5 percent of children between the ages of five to 15 years of age (Rey & Huchins, 1993). ADHD is a major health problem which consumes considerable education and health resources.

The estimates of prevalence of ADHD vary according to the different diagnostic criteria employed (Bhatia, Nigam, Bohra & Malik, 1991). In the US, the prevalence has been estimated at between two and five percent of the general population and approximately 10 to 60 percent in the clinical population (Guevremont & Barkley, 1991). A New Zealand epidemiological study in 1987 found that ADHD was the most prevalent disorder (6.7%) for seven to 11 year old children for the general population (Levy, 1993). This New Zealand estimate may more accurately represent the prevalence of ADHD in Australia bearing in mind the similarities in diagnostic criteria employed and the similar cultural norms of the two countries.

According to the Diagnostic and Statistical Manual of Mental Disorders - Fourth Edition (DSM-IV, APA, 1994) the rate of diagnosed ADHD is higher in boys than in girls and varies in the clinical population at 10:1 for pervasive and 5:1 for situational disturbances. Generally, girls diagnosed with ADHD are more likely to have intellectual or learning deficits and more affective disorders while boys tend to have more severe conduct and aggressive behavioural problems. However, it is likely that since girls with ADHD tend to demonstrate more internalised behaviours such as depression and anxiety and are less disruptive in the home and school environment, they are not as likely to present for clinical assessment. In other words, boys may be more readily identified and referred for assessment of ADHD due to their associated conduct problems and the female rates may represent an underestimate.

ADHD is currently defined in DSM-IV as a developmental disorder. The diagnostic criteria for ADHD are: an inability to focus or sustain attention on tasks (inattentive), high levels of distractibility (inability to inhibit extraneous stimuli), excessive motor activity (hyperactive) and inability to inhibit behavioural response (impulsive) (APA, 1994). In order to meet the criteria for ADHD the symptoms must be of a magnitude to interfere with a child's social, educational or occupational functioning and be pervasive across different situations (e.g. home and school) (APA, 1994).

Previous terms used to describe ADHD behaviour tended to emphasise the hyperactivity or motor-restlessness associated with this condition, for example Hyperkenesis, Hyperkinetic Reaction and Hyperkinetic Syndrome. Other terms such as Minimal Brain Dysfunction were also used to draw parallels with deficits associated with frontal lobe damage and earlier thinking about the origins of ADHD behaviour were associated with post-encephalitic conditions such as meningitis (Barkley, 1990). The term adopted by the DSM-III and the DSM classification system (APA, 1987, 1994) reflects a shift in emphasis away from excessive motor activity to deficits in focused and sustained attention.

1.2. Aetiology of ADHD

A number of different theories have been proposed to explain the aetiology of ADHD. Most of these are either biologically based, such as genetic predisposition, or propose some organic dysfunction (i.e. lead or other toxic reaction). While psychosocial factors are not excluded, and may be involved in shaping and/or maintaining ADHD behaviours (Campbell, Breux, Ewing & Szumowski, 1986; Goodman & Stevenson, 1989), the neurophysiological theories appear to be more strongly supported (Wicks-Nelson & Israel, 1991).

1.2.1. Maturation theory

ADHD has been defined as a developmental disorder, or more specifically, a disorder caused by a maturational lag in cognitive abilities. That is, the behaviours associated with ADD are not seen as deviant but rather as developmentally inappropriate (Guevremont & Barkley, 1991; Chelune, Ferguson, Koon & Dickey, 1986).

Physical immaturity of frontal limbic structures in both humans and animals has been associated with juvenile behaviours that approximate those found with ADHD children (Gorenstein, Mammato & Sandy, 1989). Luria (1973, in Lezak, 1983) suggests that the pre-frontal regions do not begin to develop until the age of four and mature by adolescence. The developmental function of these cortical areas are especially significant in conceptualising ADHD as a maturational or developmental disorder.

Several studies have shown that the differences between children with ADHD and normal controls becomes less marked by the age of nine (Das, 1984; Parasuraman & Davies, 1984; Chelune et al., 1986; Barkley, DuPaul & McMurray, 1990). By adolescence, the main symptoms of ADHD tend to dissipate although there is still some evidence to suggest that ADHD subjects continue to deviate from normals on measures of conduct problems (Gittelman, Mannhuzza, Shenker & Bonagura, 1985). It is unclear, however, whether these residual social and conduct problems experienced by ADHD adults are central or secondary to ADHD. It is likely that

interference in social and educational training in childhood results in disordered behaviour in adulthood.

1.2.2. Frontal lobe dysfunction theory.

Earlier descriptions of ADHD have reflected the historic trends in thinking about the aetiology of the disorder. Brain damage was once considered the major cause of ADHD. Following World War One there was an encephalitis epidemic in North America and children were later found to display behavioural problems characterised by high levels of inattention and hyperactivity (Barkley, 1990).

Some support for a neurological cause of ADHD has been obtained by researchers drawing parallels between ADHD and frontal lobe injured patients (Lezak, 1983; Johnson, Roethig-Johnson & Middleton, 1988). However, studies that have specifically assessed structural brain abnormalities on CAT scans in ADHD subjects have not been shown to have any irregularities (Shaywitz, Shaywitz, Bryne, Cohen & Rothman, 1983) and Rutter (1977), demonstrated that less than five to 10 percent of children with confirmed histories of brain insults and children with specific frontal-lobe damage met the criteria for ADHD. While there may be some similarity between these groups, ADHD children tend to have a broader range of problems that cannot be attributed to single site lesions.

Functional assessment of ADHD performance on a range of neuropsychological measures has shown several differences between inattentive/hyperactive children and

normal controls (Gorenstein et al., 1989). Overall, children with inattentive and hyperactive behaviours had significantly higher levels of impaired performance in short-term memory, attention, new learning, and other test of pre-frontal functions (Lezak, 1983). Parallels between ADHD subjects and people with a history of frontal-lobe damage on features of emotional lability, aggression, hypermobility and inattention have added further support to the frontal-lobe damage or organic theories of ADHD (Mattes, 1980). However, these comparisons are generally made with a small number of brain injured patients with localised lesions in a variety of different cortical areas. The behavioural sequelae associated with ADHD is more likely to be explained by more diffuse rather than localised brain damage (Lezak, 1983).

1.2.3. Inhibition theory of ADHD.

Studies assessing brain wave activity and cerebral blood flow using EEG and PET scans have found that ADHD children have less frontal-lobe reactivity when performing cognitive tasks than normal controls (Satterfield, Cantwell & Satterfield, 1974; Grodinsky & Diamond, 1991; Chelune et al., 1986). More specifically, ADHD subjects have a reduction in the cortical and sub-cortical regions and orbital-frontal connections with the caudate nucleus (Guevremont & Barkley, 1991). These structures and their associated neural pathways have been implicated in the

regulation of arousal and inhibition of cortical functions (Stuss & Benson, 1986; Lezak, 1983).

Satterfield et al. (1974) argued that the hypermobility noted in ADHD was caused by the under-arousal of the reticular activating system (RAS). ADHD was conceptualised as the inability to stimulate the behavioural inhibition processes. It was this proposed lack of inhibition that made it difficult for subjects to subsequently focus and sustain attention.

Stimulant medication was proposed to activate (or increase) RAS arousal, reducing symptoms of inattention and hyperactivity. This model assumes that there is a specific locus of deficit in ADHD children and further that these stimulants caused a response selectivity in ADHD subjects which improves attentional functioning compared to a control group.

The inhibition theory has wide clinical acceptance as superficially, it appears to explain the paradoxical effect of stimulant medication in ADHD children. It was argued that these medications stimulated the inhibition processes of the brain allowing ADHD children to better regulate cortical arousal and disinhibition resulting in improved behaviour (Klorman, Brumaghim, Fitzpatrick & Borgstedt, 1991).

Anecdotal evidence from behavioural assessments of ADHD children by parents suggests that they show lower levels of hyperactivity, inattention and impulsivity following stimulant medications (Barkley, 1991). In

addition, several researchers have demonstrated that children diagnosed with ADHD improve on psychometric and neuropsychological measures of attention and impulse control following stimulant treatment (Keith & Engineer, 1991; Klorman, Brumaghim, Fitzpatrick & Borgstedt, 1991; Buhrmester, Whalen, Henker, Macdonald & Hinshaw, 1992; Carlson, Pelham, Milich & Dixon, 1992).

The paradoxical effect of the stimulant medication has been challenged by Rapoport et al. (1978). They were able to demonstrate that the administration of stimulant medication to hyperactive and normal control children, increased RAS activity in both groups. The authors concluded that there was no specific response selectivity among clinical and control groups as both had increased cortical arousal under stimulant conditions. Similarly, both ADHD and controls had been found to improve their performance on neurocognitive tasks following medication demonstrating that stimulants do not have a unique effect for ADHD subjects (Levy, 1993).

The frontal limbic models of ADHD potentially provides a link between the neurophysical, functional and maturation features of the disorder. While a specific mechanism has not been clearly identified, researchers have implicated neurochemical abnormalities in the aetiology of ADHD (Guevremont & Barkley, 1991). Dopaminergic and noraginergic abnormalities have been considered the most likely causes of ADHD as they have been found to have a wide range of effects in other psychological conditions -

for example, depression, anxiety & schizophrenia (Braff & Huey, 1988). The diffuse effect of neurochemical changes provides a plausible explanation of the interaction between the neurophysical structures and pathways and the broad ranging symptoms associated with ADHD.

1.3. DSM-IV Criteria

Early formulations by the DSM systems defined ADHD as a disorder of inappropriate motor regulation for example, hypermobility and hyperactivity (APA, 1980, 1987). However, the DSM-IV reflects a shift in the current interpretation of the ADHD as a disorder of inattention as well as retaining its historical characterisations in terms of hyperactivity. At least six symptoms from both the inattentive (A1 criterion) and hyperactive/impulsive (A2 criterion) of the DSM-IV are required to fulfil the diagnosis. Where both criteria (A1 and A2) have been met for a period of at least six months, ADHD (Combined Type) is specified. If criterion A1 has been met for at least six months but criterion A2 has not, a diagnosis of ADHD (Predominantly Inattentive Type) is specified. Alternatively, where criterion A2 has been met for six months and A1 has not, a diagnosis of ADHD (Predominantly Hyperactive-Impulsive Type) is given.

There have been a number changes in the diagnostic criteria of ADHD since the DSM-III-R. Firstly, criterion C now specifies that the symptoms must be pervasive across two or more settings such as school or home. This change

is consistent with the ICD-10 (Gueremont & Barkley, 1991) and tends to better identify children who have a significantly higher level of clinical dysfunction in the home, social and educational settings. Assessment of ADHD with pervasive behaviours in the clinical range should provide a better understanding of the disorder-specific deficits associated the DSM-IV diagnosis. Previous research adopting DSM-III-R has employed children with less severe forms of the disorder (i.e. situational specific symptoms rather than pervasive disturbances).

Secondly, the DSM-IV recognises the ADHD type behaviours as being "maladaptive and inconsistent with developmental level" (APA, 1994, p.83). This change is very significant as it means that the child's mental age must be taken into account when making a diagnosis, and that the subject's ability to sustain attention must be below their overall level of intellectual functioning (IQ).

Thirdly, where the symptoms of inattention and impulsiveness/hyperactivity are better accounted for by another mental disorder (e.g. Pervasive Developmental Disorder, Mood Disorder or Anxiety Disorder) the diagnosis of ADHD is not given (Criterion E). This latter change facilitates differential diagnosis of ADHD and takes into account other environmental, physical and social factors that may contribute to behavioural disturbances in children.

Barkley (1994) argues that the changes made in the DSM-IV criteria need further refining and should include

cut-off scores specifying symptoms for different age groups, as it is unlikely that older children and adults would meet criterion A. In other words, while the range of specific symptoms may be readily displayed in younger children as a developmental disorder, the symptoms would typically lessen as children got older. Age specific norms would facilitate ADHD diagnosis of these older children and adults.

In the normal population, younger children may exhibit behaviours similar to ADHD children and Barkley therefore suggests that only those behaviours exceeding the highest clinical range (93rd percentile) should be counted in making a diagnosis. However, while the specification of a high clinical range might be helpful in diagnosing ADHD, it is unlikely that ADHD children will obtain scores above the 93rd percentile on behavioural profiles across more than two settings leading to potential false negatives (Barkley, 1994).

The scales typically used to identify behaviours in the clinical range (Child Behaviour Checklist; Conner's Parent Teacher Rating Scales) have several problems. Thus, while parent and teacher ratings of a child's behaviour are highly correlated, parents tend to score behaviour as worse on these scales compared to teachers (Edelbrock & Achenbach, 1980; Edelbrock, Greenbaum & Conover, 1985). It is likely that teacher ratings are more accurate as they are able to compare subject with peers of the same age group on specific items on the scales.

Additionally, behaviour scales tend to norm children's behaviour by broad-band chronological age ranges such as six to 12 years inclusive, instead of providing separate norms of children of different age groups. These age groupings, make it difficult to get age-specific norms for individual behaviour. For example, There is no differentiation between say a child aged six and a child aged nine.

Even with a developmental disorder, it is expected that children's behaviour would change as they became older and current behavioural scales do not provide separate norms for children of different mental ages. Barkley (1994) suggests that children with a low IQ should have their behaviours assessed using mental, rather than chronological age. This latter qualification is useful as it takes into account the developmental discrepancies both within and between different age ranges.

Barkley's suggestions for more stringent ADHD diagnostic criteria reflect a general push by the profession to further clarify the parameters of the disorder. In fact, there has been much criticism querying the validity of the notion of ADHD and what it is and is not. The increased unregulated use of the term has threatened the integrity of the diagnosis as it no longer reflects behaviours at the abnormal end of the spectrum.

1.4. Diagnostic Validity of ADHD Criteria

Debate continues over the validity of the diagnostic criteria for ADHD. Rutter (1977) and Robins (1992) argue that in order to validate a diagnostic entity it must be differentiated from other clinical disorders in terms of symptomatology, aetiology, course of the disorder and response to treatment. Clinically, the diagnosis of ADHD is not distinguishable from other diagnoses as a unique syndrome on the basis of the criteria list in Section 1.3.

While children with ADHD have been shown to be different from non-ADHD children on a number of behavioural and psychometric indices, they are not convincingly different from other clinical groups such as Conduct Disorder (CD) Developmental Delay (DD), Learning Disabilities (LD), etc. (Garfinkel & Amrami, 1992; Power, 1992).

The main features used to define ADHD are not diagnostically specific as they are used to identify other disorders such as CD and Oppositional Defiant Disorder (ODD). ADHD has a high rate of co-morbidity with LD, CD and ODD (Whalen, 1989; Rey & Hutchin, 1993). For example, in a clinical population up to 90% of ADHD cases may co-exist with CD (Sabatino & Vance, 1994; de Sonneville, Njioktjien & Hillhorst, 1991).

The high level of co-morbidity between ADHD, CD, ODD and DD has been the main challenge to ADHD diagnostic validity. Cantwell and Baker (1992) assessed 80 ADHD children on a number of clinical indicators including the

DSM-III-R (APA, 1987) criteria. They found that while ADHD subjects tended to exhibit high levels of aggression and CD behaviours, conduct problems increased as a function of high impulsivity and hyperactivity scores on behavioural measures. It is likely therefore, that conduct problems may be a behavioural manifestation of more severe forms of ADHD (indicated by higher levels of social dysfunction) rather than a separate disorder per se.

It has also been argued that CDs are more specifically related to different sub-types of ADHD (Barkley, 1994). ADD (without hyperactivity) is primarily characterised as inattentive and disorganised (daydreaming) behaviours, while ADHD is characterised by greater levels of hyperactivity and impulsivity (Lahey & Carlson, 1991). ADHD children tend to be given a co-diagnosis of CD while ADD children have higher rates of co-morbid Depression and Anxiety disorders (Barkley, 1990).

The change in emphasis from hyperactivity to attention deficits in ADHD has also raised questions regarding the symptom specificity of the diagnosis. Firstly, deficits in attention have been reported in children with LD, CD, DD, Depression and Schizophrenia (Lezak, 1983; Power, 1992; Robins, 1992). Secondly, the construct of attention has not been clearly defined. Deficits in attention have been inferred from indirect observations of impulsiveness and hyperactivity and scores on behaviour scales. While these measures have been found to have a high correlation with laboratory tests and neuropsychological measures of

attention, researchers have found it difficult to define attention as an uniquely independent behavioural construct (Power, 1992).

Several researches have demonstrated significant differences between ADHD subjects and normal controls on measures of sustained attention, using Continuous Performance Tests (CPT). These tests are vigilance tasks and the scores used to assess performance, for example, omission errors, commission errors, and response variability, have been found to correlate with behavioural measures of the disorder (inattention, impulsivity and difficulty sustaining attention).

However, the results obtained from ADHD research using measures of CPT are inconsistent and difficult to interpret. This is primarily due to the different methodologies employed by various researchers and the absence of a clear theoretical model in which differences in performances on these measures can be defined, assessed and interpreted.

1.5 Performance of ADHD children on measures of attention

A number of researchers have found differences between ADHD and normal control subjects on a range of behavioural, psychological and neuropsychological tests (Haperlin et al., 1989; Gorenstein et al. , 1989; Grant, Ilai, Nussbaum & Bigler, 1990). Generally, these studies have shown significant deficits in higher cognitive processing including short-term memory, planning/ organisation,

cognitive flexibility and attention in ADHD subjects (Chelune et al. , 1986; Gorenstein et al., 1989; Lezak, 1983; Grodzinsky & Diamond, 1992; Power, 1992).

Earlier conceptualisation of ADHD as a hyper-mobility disorder led researchers to examine differences between clinical and normal groups using a range of devices to detect increased physical mobility in ADHD subjects. For example, the use of 'wiggle cushions' were used to demonstrate that ADHD children fidgeted and shifted in their seats in class more than normal controls (Barkley, 1990). Other tests (e.g. Stop No Go, Stroop test) have shown that ADHD children have more difficulty disengaging from primary task (disinhibition) and have a higher level of inappropriate responding to tasks (impulsivity). These results are consistent with behavioural manifestations of ADHD and tend to suggest a common underlying mechanism that is responsible for the initiation, regulation and disinhibition of motor response (Fischer, Newby & Gordon, 1993).

The change in emphasis in ADHD to attentional deficits, as reflected in the DSM-III, has resulted in the CPT being widely adopted as the definitive diagnostic tool in ADHD assessment and research. The CPT was adapted by Rosvold, Mirsky, Sarason, Bransome and Beck (1956) as a measure of sustained attention at a time when performance on vigilance tasks was conceptualised as a unitary phenomenon (Corkum & Seigal, 1993). The CPT was originally developed from studies in human vigilance in which

Mackworth (in Corkum & Siegel, 1993) investigated an individual's readiness to respond to irregular critical events over a period of time. The CPT typically requires subjects to identify target visual or auditory stimuli from a series of numbers or letters. Performance is assessed by the number of hits, commission errors, reaction time and response variability.

Typically, studies employing CPT measures have found that children diagnosed with ADHD average fewer hits, more commission errors, slower reaction times and increased response variability than normal control groups (Barkley et al., 1990). These scores are said to correlate with behavioural measures of attention, impulsivity and hyperactivity (respectively) from parent and teacher ratings of ADHD symptoms (Haperlin et al., 1990; Sonneville et al., 1991; Power, 1992). CPT indices have also been found to significantly correlate with other neuropsychological measures of inattention and impulsivity. These include the Freedom from Distractibility Factor (derived from subtests of WISC), Trail Making Task and Stroop respectively (Grant et al., 1990; Grodinsky & Diamond, 1991)

However, not all studies have found a relationship between measures of ADHD behaviour and reduced performance on CPT tasks (Lovejoy & Rasmussen, 1990). Studies by Trommer, Hoeppner, Lorber and Armstrong (1988) demonstrate that up to one third of ADHD patients fail to perform differently from normal controls on CPT tasks. The high

rate of false-positive classification of ADHD using the CPT has raised several questions regarding the utility of the CPT tests as a diagnostic tool. However, Fischer et al., (1995) argue that the rate of false-positives in the clinical population is rare and that it is the rate of false negatives that is high (27% to 85%) due to ADHD classification and age of the subjects employed. When ADHD rating were based on clinical scales, Fischer et al. stated that there was an agreement rate of 70-80% of convergence between CPT performance and clinical diagnosis of ADHD.

Despite the high number of false-negatives on CPT measures, Fischer et al. (1995) suggest that some ADHD subjects may be qualitatively different to those who perform poorly on this measure. That is, ADHD subjects with more normal scores on CPT performance tend to have significantly lower scores on behavioural measures of inattention with higher rates of co-morbid CD and other psychosomatic problems than ADHD subjects who performed poorly on this measure. The majority of ADHD children with high levels of aggression have also been found to be more impulsive than inattentive compared to ADHD with lower levels of aggression (Haperlin et al., 1990).

These findings suggest that ADHD sub-groups may not perform uniformly on measures of attention. ADHD subject with CD may represent a more severe sub-group of the disorder compared to those with low levels of impulsivity and aggression. Further research is needed to assess the relationship between these factors and provide information

regarding the effects that symptom severity and level of dysfunction have on CPT performance.

1.5.1 Effect of co-morbidity on ADHD performance

The high co-morbidity of ADHD with other known childhood psychopathologies has made it difficult for researchers to identify the specific cognitive and behavioural parameters of the condition. Failure to demonstrates unique deficits in attention in ADHD from CD, LD and other known psychopathologies has been the main challenge to the validity of the disorder as a separate diagnostic entity.

Haperlin et al. (1990) investigated the effect of aggression (a primary feature of conduct disorder) on vigilance performance, to assess the validity of hyperactive and aggressive sub-groups as divided in the IOWA Conner's behaviour scales. Using a CPT, Haperlin et al. compared four sub-groups of children based on high and low levels of hyperactivity and aggression as measured by the IOWA Conner Teachers' Questionnaire. Results demonstrated that predominately hyperactive subjects (with low levels of aggression) made significantly more errors of omission than the other groups, suggesting high levels of inattention. Subjects with high levels of hyperactivity and aggression made more errors of commission reflecting increased impulsivity in this group. Predominantly aggressive (with low levels of hyperactivity) could not be differentiated from the control group on any of the CPT

measures. These findings demonstrate the role of co-morbid levels of aggression (a primary indicator of CD) in ADHD functioning and support a distinction between two types of ADD based on the presence or absence of hyperactivity.

Children with a persistently high level of delinquency have been shown to demonstrate a unique pattern of performance on a number of neurophysiological measures (including EEG) compared to normal control groups. This is argued to be indicative of anterior cerebral dysfunction (Yeudall, Fromm-Auch & Davies, 1982).

While oppositional or conduct behaviours are characterised by higher levels of inattention, impulsivity and hyperactivity, the high co-mobidity rate between ADHD and CD makes it difficult to extrapolate the unique contribution that these disorders have on CPT performance. The difficulty in identifying the unique parameters of these control disorders raises further questions concerning the validity of these diagnoses.

August and Garfinken (1989) argue that rather than representing two separate disorders, ADHD subjects with co-morbid CD simply represents the more severe case of ADHD. That is, ADHD children are conceptualised as being on a continuum of severity. At one end, subjects may have symptoms more akin to ADD, while at the other end it is ADHD. Behavioural features of severe ADHD with a high level of dysfunction parallel those found in CD.

Comparative studies assessing the difference between ADD and ADHD have failed to demonstrate significant

differences between performance on CPT. Barkley et al. (1990) compared ADHD, ADD, LD and control subjects on CPT performance. Their results showed that the ADHD group made significantly more commission and omission errors than LD and control groups, while the ADD group made more errors of commission than LD but not controls. No differences were found between the ADHD and ADD groups on CPT scores. However, both groups were judged to have displayed significantly more off-task behaviours than LD subjects. While not statistically significant, ADHD subjects were found to make twice as many commission errors as ADD subjects.

Since commission errors were found to correlate with behavioural indices of inattention and impulsivity, Barkley et al. (1990) concluded that ADHD subjects were more impulsive than ADD subjects. More specifically ADHD subjects were argued to have deficits in the focused, sustained and disinhibition components of attention as the number of commission errors was found to positively correlate with behavioural indices used to assess inattention and impulsive behaviours.

This conclusion should be viewed with a number of caveats. Firstly, while the ADHD group was found to demonstrate some qualitative behavioural differences with more off-task behaviour, it is not clear whether experimenters were blind to the group membership of subjects. That is, it is likely that experimenters may

have been objective in their evaluations of off-task behaviours than if they were blind to subjects' diagnoses.

Secondly, although the number of commission errors was higher in the ADHD group than the ADD group it was not significantly different. In other words, these subjects could not be statistically differentiated on commission errors despite the correlation with measures of error and impulsivity. Therefore, the conclusion that ADHD subjects are more inattentive or impulsive than ADHD has not been supported by the data.

Finally, subject ratings were entirely dependent on parental and teacher assessments. It is likely therefore, that rating disagreement may have resulted in subjects being given a diagnosis of ADHD even though they did not show pervasiveness of symptoms nor met the criteria for more than one diagnosis (Haperlin et al., 1990; Barkley et al., 1990).

Further research by Barkley et al. (1992) demonstrated that although subjects with ADHD made more omission and commission errors than normal controls and LD on CPT, the ADHD group could not be differentiated from the ADD. That is, unique patterns of performance on the CPT could not be established distinguishing different groups on measures of inattention. These findings fail to support those of Haperlin et al. (1990) and indicate that deficits associated with ADD are not different from those found in ADHD.

In an attempt to further assess the validity of ADHD diagnosis, Robins (1992) compared ADHD and LD subjects on a number of neuropsychological tests. He found that compared to the LD group, ADHD subjects made more errors when speed of responding was stressed. That is, they consistently compromised accuracy of response for increased speed. These findings suggest that ADHD subjects have difficulty inhibiting behavioural responses and add validity to the third criterion of disorder (c.f. impulsivity).

While overall performance on the sustained attentional tasks (CPT) differentiated normal controls from the disordered groups, it was not able to discriminate between LD and ADHD groups. However, ADHD subjects are well known to show normal sustained attention when tasks are novel and high rates of immediate reinforcement occur. Their sustained attention difficulties are more apparent when undertaking more mundane and familiar tasks where focussed effort on a sustained basis is required. (Robins, 1992).

Interestingly, ADHD subjects were found to have greater commission variability across trials compared to LD and controls. This increase in commission error was argued to be evidence of poor regulation of attentional resources. It suggests that ADHD subjects may be more susceptible to boredom and have trouble regulating arousal of their central nervous system (Douglas, 1980, in Power, 1992; Barkley et al., 1992).

1.5.2. Effect of task variables on ADHD CPT performance

A number of contextual variables such as time of day, duration of task, complexity of task and level of reinforcement have been shown to affect performance on vigilance tasks (Warn & Jerison, 1984). Other variables affecting performance of CPT include: target/non-target ratio and rate of stimuli presentation. Power (1992), who assessed some of the effects of contextual variables on CPT performance in ADHD subjects, found that the absence or presence of the experimenter was also a significant factor. That is, when the experimenter was present, ADHD subjects displayed greater sensitivity to target stimuli compared to when the experimenter was absent. The adult supervision appears to enhance performance. It is likely that the experimenter's presence act as an external visual cue for subjects which increased their internal awareness of their performance, and provided feedback to facilitate self regulatory control. This finding lends support to theories that link inattention/impulsivity to deficits in rule governed behaviour (Barkley, 1990; Power, 1992).

The types of vigilance tasks employed tend to produce varied results due to inherent different information processing demands. Generally, tasks that place higher demands on subjects (low or high frequency of target ratio, increased task complexity and so on) produce greater performance deficits in the ADHD groups (Power, 1992).

Chee, Logan, Schacher, Lindsay and Wachsmuth (1989) hypothesised that groups deficient in attention should display greater decrements in performance on tasks that demanded greater attentional resources. In a two part study employing 51 clinical and 36 normal controls, Chee et al. manipulated the display rate and interstimulus interval rate of a simple vigilance task. ADHD subjects were found to display unique patterns of performance on higher demanding tasks, defined as those with a lower or high stimulus-to-target ratio or a faster rate of target presentation.

It was argued that even lower rates of stimulus-to-target ratio demanded more attention than moderate presentation rates as subjects tended to get bored and distracted more easily. However, the difference between the two groups became less apparent when stimulus rate and display time were in the moderate range. This latter finding is interesting and suggests that moderate stimulus to target ratios are less demanding and place fewer cognitive demands on subjects. Further, when the task is less complex, ADHD subjects perform as well as their control counterparts.

On the whole, research assessing the performance of ADHD subjects on CPT tasks lacks the support of clear theoretical models in which the differences between groups can be understood (Halperin et al., 1990; Lovejoy & Rasmussen, 1990). Interestingly, the literature regarding theories of vigilance has been largely ignored in ADHD

research despite the obvious relationship between these two areas and the similar tasks employed. In order to understand more fully the deficits associated with ADHD on CPT tasks, continuing research should take into account the variables known to affect sustained attention.

1.6 What is vigilance?

The term vigilance has been used synonymously with sustained attention or the process of maintaining attention over a period of time (Mackworth, 1970). Head (1923, in Davies & Tune, 1970) and Davies & Parasuraman (1982) referred to vigilance as a state of optimal physiological efficiency which correlates with the arousal (or receptive) component of attention.

Vigilance is used more restrictively than attention as it refers to one part of the attention processes. More specifically Davies and Parasuraman (1982) defined vigilance as an observer's ability to detect signal changes within a specific visual field over a continuous period of time. The primary focus of vigilant behaviours is maintaining attention over a duration of time. Mackworth (1970) asserted that measures of sustained attention should be taken over a period of at least 30 minutes in order to assess decrement in performance over time. Assessment of sustained attention over shorter time periods may fail to demonstrate changes in performance.

Most of the literature assessing CPT performance in ADHD children has generally used measures of three to nine minutes duration. Those studies using the longer period of time have been more likely to demonstrate decrements in performance on these measures (Douglas, 1983). In order to compare group by time interaction on performance decrement between ADHD and normal control subjects, tasks may need to measure performance across longer periods of time to assess differences in rate of decrement between ADHD and controls.

1.7. Utility of the CPT as a measure of sustained attention

The CPT is a vigilance task which has been employed extensively by researchers as a measure of sustained attention (Gordon, Di Niro & Mettelman, 1988). Several studies have shown significant correlations with tests known to measure attention (e.g. Digit Span, CHIPASAT) and behavioural indices of attention deficits (Klee & Garfinkle, 1983; Gorenstein et al., 1989; Chelune et al., 1986; Barkley, 1990). However, due to differences in subject criterion, task type, duration of task, indices obtained and other factors, results obtained from this literature are not conclusive.

The Gordon Diagnostic System is one of the most common CPT tests used in ADHD research. This test consists of six separate tasks which are based on two basic paradigms (Gordon et al., 1988). Two tasks include a delayed test which is a differential reinforcement schedule of six seconds designed to assess the subjects' ability to inhibit

seconds designed to assess the subjects' ability to inhibit responses. The remaining tasks are derived from models of vigilance tasks in which subjects are required to respond only when a sequence of numbers appears, for example '1' followed by '9'. A parallel task requires that subjects respond to '3' followed by '5'. Both tasks are nine minutes in duration.

A similar 60 second task is available for children under seven years and they respond to '1' followed by '0'. A distractibility task, similar to the above, has numbers appearing in three separate columns of a visual display and subjects are required to respond only to number sequences in the middle column, while ignoring the other columns.

The numbers of hits, misses, commission error and reaction time on CPT tasks have been seen as assessing level of attention, inattention, impulsivity and hyperactivity respectively (Barkley, 1994; Gordon et al., 1988). However, since performance on CPTs requires a number of cognitive and behavioural responses, deficits in performance could reflect problems with either sensory input, information processing, response selection or motor response. It is for these reasons that the CPT task is limited - it only measures the final motor response and fails to identify specific attentional processes/deficits during a vigilance session.

A number of researchers have demonstrated a significant correlation between CPT performance and measures of hyperactivity, impulsivity, WISC-R Freedom from

Distractibility factor and ADHD rating scales (Klee & Garfinkel, 1983; Gordon, 1988; Grant et al., 1990; Barkley, 1994). These findings have been seen as providing evidence of convergent validity of CPT as a measure of inattention and distractibility. However, the constructs underlying measures used to validate the CPT have themselves not been clearly defined by the research. The relationship between CPT measures and other tasks may be indirect and a product of "attention" rather than a unitary measure of the construct itself.

These considerations raise questions regarding the criterion for diagnosing ADHD subjects and the need to employ more stringent criterion as recommended by Barkley (1990). While ADHD subjects may score higher on measures of impulsivity, hyperactivity and so on, they tend to have high co-morbid level of aggression. Children with CD (of which aggression is a primary feature) also score poorly on CPT tasks. Additional research investigating the nature of the relationship between behavioural correlates of inattention and CPT performance is needed to demonstrate the validity and reliability of the CPT as a measure of deficits in sustained attention.

1.8. Inability to sustain performance across time in ADHD

Most of the research employing CPT has predominantly assessed differences in total percentage of correct and incorrect responses. However, van der Meere and Sergeant (1988, in Seidel & Joschko, 1990, p.227) have argued that

"..in order to demonstrate deficits in sustained attention both a main effect for time and group by time interaction must be shown".

Researchers using CPT as a measure of sustained attention in ADHD subjects over a period of time have found different results (Fischer et al., 1993; Godzinsky & Diamond, 1990; Grant et al., 1990; Seidel & Joschko, 1990; Carlson, Pelham, Milich & Dixson, 1992). In a review of the literature, Corkum and Siegal (1993) identified several major differences in selection criteria, definition of ADHD, task, contextual and situational variables. It was concluded nevertheless, that in spite of the inconsistencies in the results there are differences between normals and ADHD subjects on CPT measures. However, the research has not provided evidence of a specific deficit in sustained attention in children with ADHD since subjects were not shown to differ from other clinically diagnosed groups.

In a review of the literature, Corkum and Siegal (1993) cited five studies that assessed the effects of time on ADHD performance on CPTs. Only one study (Sykes, Douglas & Morgenstern, 1973) demonstrated a significant group by task by time interaction: ADHD subjects showed a greater deterioration in performance across time than controls.

The main difference between these latter studies and the others reviewed by Corkum and Siegal (1993) is that Sykes et al. (1973) employed a successive discrimination

task and used subjects recruited from a clinical population. These successive tasks have been argued to differ from simultaneous discrimination tasks as the inherent memory load of the successive tasks are greater (Parasuraman & Davies, 1984). Further, Davies and Parasuraman (1982) in a review of vigilance literature found that vigilance performance only declined on successive tasks rather than simultaneous CPT tasks. They found that some ADHD subjects appeared to have greater difficulty in sustaining performance on tasks requiring effort.

Of the 13 studies reviewed by Corkum and Seigel (1993), seven employed successive tasks while three used both successive and simultaneous tasks. It was concluded that differences between normal and clinical groups occurred regardless of the type of tasks employed. However, the interaction between task type and time was not directly assessed.

Two studies which did compare vigilance performance change over time for different tasks (time-by-task interaction) used a between-subject design employing different subject groups for each of the tasks. One of studies was by Sykes et al. (1973) who used a clinic-referred sample which was younger than the controls and age was not used as a covariate in the design. It is unclear therefore whether the group differences were due to subject group or age.

In a two part study, Seidel and Joschko (1990) assessed difficulties in sustained attention in ADHD children. The main aims of the study were firstly to investigate the effect of age on performance in a normal sample, and secondly to compare CPT performance of ADHD subjects with normal controls. Based on earlier research by Sykes et al. (1973), Seidel and Joschko used experimenter-paced, simultaneous and successive CPT using target letters of X and A-X respectively. It was argued that since individual performance on these different tasks have been shown to correlate highly, and the sum of the two tests was more reliable, the researchers combined the measures of both tasks for analysis.

Using both traditional measures of CPT and Signal Detection indices Seidel and Joschko (1990) demonstrated that younger children's performance declined significantly more than that of older subjects using measures of correct hits, sensitivity, reaction time and variability of response. Post hoc analysis subsequently found a significant time effect for six and seven year olds for both hit rates and level of sensitivity but not reaction time or variability. No significant differences were found between groups on measures of response bias.

Comparisons between ADHD subjects and normal controls found that the ADHD subjects' number of hits declined significantly over three time periods. The ADHD subjects' level of stimulus sensitivity also declined over time compared to normal controls. However, comparisons between

time periods found only non-significant differences. Further, no significant group by time effects were found on reaction time, variability, false alarms or response bias for group by time interaction.

It was concluded that the main difference between ADHD and normal groups was their ability to maintain detection of infrequent target stimuli over time. This reflects a decrease in sustained attention rather than changes in response strategies and level of motivation (false alarms and response bias).

These findings are generally consistent with those of Sykes et al. (1973) and indicate that there is a marked differences in performance between ADHD and normal groups on measures of sustained attention. While there is a significant developmental influence on children's CPT performance decrement (with younger children producing greater deficits), the effect of age on the time-by-group interaction was not assessed. Research addressing this issue would provide further information on the developmental course of ADHD and its deficits.

The summing of data from both tasks across CPT measures may have obscured task effects on performance. This treatment of the data therefore failed to clarify how the demands of the different tasks contributed to performance decrement in ADHD and younger children. While Seidel and Joschko (1990) stated that children's performance on the successive task paralleled performance

on the simultaneous task, these scores were not reported separately.

The issues regarding vigilance decrement and task type need further investigation. While the factors involved in maintaining vigilance performance and vigilance decrement are assumed to be different, the additional memory load of successive tasks appears to have a greater effect on the decline in performance over time and may be more central to deficits associated with ADHD.

Since ADHD children tend to show greater levels of impairment in more demanding situations (Guevremont & Barkley, 1991), it is reasonable to argue that they will have a faster rate of performance decrement on successive tasks relative to normal controls.

1.9 Theories of performance decrement on vigilance tasks

A number of different theories have been proposed to account for vigilance performance and its decrement over time. Primarily, these have been data driven and tend to depend on the types of tasks employed. For example, researchers using low frequency, low stimulating tasks tend to adopt theories of CNS arousal, while those adopting tasks which are highly stimulating and designed to divide attention between tasks, tend to favour theories such as resource allocation (Davies & Tune, 1970). Similarly, different theories of vigilance have also tended to reflect general trends in psychology.

Early theories put forward to explain the decrements in vigilance performance were based on learning models of behaviour. Mackworth (1970) argued that observers learnt to inhibit responses to target stimuli as they habituated to repetitive stimulation of neutral background events. Broadbent (in Davies & Tune, 1970) also used an inhibitory framework to explain vigilance performance. He argued that the attentional response to non-target stimuli extinguished due to the lack of reinforcement. Further, Broadbent claimed that this extinguished response was generalised to critical signals (targets) causing a decrement in performance.

Mathews and Holley (1993) argue that differing cognitive factors in different types of vigilance tasks determine overall performance: tasks with a higher cognitive load (successive tasks) tend to require greater attentional resources than those that place fewer demands on working memory such as the simultaneous tasks.

It is argued that the system for processing information has a limited capacity, and that more complex tasks take longer to respond to than simple ones because of the higher cognitive processing required (Sternberg, 1975).

According to the information-processing model of cognitive functioning, there are several stages of receiving and responding to incoming stimuli. The first stage is a pre-attentive stage in which individuals ready themselves to select incoming information for further processing. Neisser (1967) argues that without a pre-

attentive stage, the mechanisms for selective allocation of information would become overloaded and slow down or abort further processing.

Few theories have adequately accounted for the factors that maintain performance on vigilance tasks and those that cause its decrements. While these constructs are related, it is likely that the processes that underlie sustained attention differ from those that cause performance to decline over time. Models of attention dysfunction in ADHD children need to distinguish between vigilance performance and vigilance decrement to adequately account for the differences in performance on CPT tasks compared to normal controls.

1.10 Aims and hypotheses of the present study

The overall aim of this research is to evaluate performance of ADHD subjects on tasks requiring sustained attention. More specifically, the central aim was to investigate the effect of time on performance on both simple (simultaneous) and complex (successive) CPT's on ADHD subjects relative to normal controls.

If information processing/resource allocation theory is supported, ADHD subjects should show a greater decrement in performance on a complex task than a simple one. Conversely, the stimulation models of ADHD function predict that these group differences will be maintained across both simple and complex tasks.

A further aim of this study is to assess the effects of age and IQ with ADHD performance. Maturational theories predict that ADHD children will lag behind normals controls on attentional ability. In this case, it would be predicted that both older ADHD and control groups would perform better than their younger counterparts on CPT measures. However, children with ADHD would be expected to lag behind the non-clinical group.

Finally, the study aims to assess the relative utility of the ADHD and CD diagnoses in predicting performance on CPT measures. It would be expected that ADHD rather than CD behavioural correlates would be the best predictors of performance on CPT tasks if ADHD subjects have a specific deficit in sustained attention (that is unique to the diagnosis).

Comparative evaluation of ADHD performance on CPT measures, independent of age, IQ and CD, would provide information regarding the specific deficits associated with ADHD, adding support to the DSM-IV criteria. In addition, assessment of performance differences on tasks with varying demands on information processing functioning could further our understanding of the aetiology or mechanisms by which deficits in attention may occur.

CHAPTER 2: Method

2.1. Design

The present study was designed to assess quantitative and qualitative differences between ADHD children and normal controls on both a simple and complex vigilance tasks. The independent variables in the study were the presence or absence of ADHD. The main dependent variables were vigilance performance based on scores on CPT simultaneous and successive tasks using traditional measures of number of hits (which is inversely related to the number of omissions), commission errors and response latencies (reaction time).

2.2. Subjects

A total of 51 boys between the ages of seven and twelve years (mean = 113.07 months, SD = 16.14) took part in this study. The control group of 32 boys had a mean age of 112.94 months (SD=16.88) and were students from two local primary schools in the Cowra area, Central Western Region of New South Wales. The selection of control subjects was random and completely voluntary. The recruitment of these subjects was by initial survey and is further outlined in section 2.5.1.

The clinical group of 19 boys had a mean age of 113.94 months SD=15.23) and were referred by a local Paediatrician for assessment of ADHD. Referrals were based on the presence of inattentiveness (excessive distractibility, inability to concentrate and complete tasks), hyperactivity

(running or moving a lot of the time, inability to sit still and generally fidgety) and impulsivity (talking out of turn acting without thinking, dangerous or reckless play). DSM-IV diagnosis was determined by the presence of eight or more symptoms rated with a severity score of two or higher using the ADHD rating scale.

ADHD subjects were further assessed on DSM-IV criteria of Attention Deficit Hyperactivity disorder indicated by:

I) inappropriate levels of inattention for mental age,

ii) symptoms of hyperactivity-impulsivity,

iii) symptom onset prior to 7 years of age,

iv) duration of symptoms of a least 6 months which were pervasive across a variety of settings,

v) normal range of intelligence.

In addition, ADHD subjects were required to obtain a high clinical score of at least 1.5 SD above the mean for age on Inattentive and Hyperactive factors of the Child Behaviour Check List for ages 4-18, Parent Rating Scale (Achenbach, 1991). Subjects who scored lower than 1.5 SD on Hyperactivity scale were classified ADD without hyperactivity. Subjects with Delinquent and Aggression scores above 1.5 SD were given a co-diagnosis of CD (Achenbach & Edelbrock, 1983; Barkley, 1990; Achenbach 1991).

As a result of consultation with the Paediatrician children with psychosis, developmental delay or known neurological damage were excluded from the study.

Similarly, subjects receiving stimulant medication were excluded from the study. None of the clinical sample had been on stimulant medication prior to being referred for assessment.

2.3. Experimental Measures

2.3.1 Wechsler Intelligence Scale for Children - Revised (WISC-R)

The WISC-R was employed to assess verbal intelligence. This is the most available and reliable measure of overall general intelligence (Wechsler, 1974) and provided an opportunity to compare directly with previous studies using this scale.

Scores on the Verbal Scale have been shown to highly correlate with the Full Scale scores and was considered the best estimate of overall functioning (Wechsler, 1974). The Verbal Scale consists of five main subtests including Information, Similarities, Vocabulary, Comprehension and Arithmetic. These subtests are all administed verbally except for the first four items on the Arithmetic test. Since the Arithmetic task is the least predictive of Verbal and Full Scale intelligence (Weschsler, 1974), it was omitted from the battery to reduce administration time. Administration and scoring of these tasks were in accordance with the instructions in the manual.

2.3.2 Attention Deficit Disorder Rating Scale

The ADHD rating scale was developed by DuPaul (1990) based on the DSM-III-R diagnostic criteria for ADHD. The original scale of 14 items was used to determine the presence and severity of ADHD symptoms with age and sex appropriate cut-offs for both parent and teacher ratings. The scale yields separate scores on inattention and hyperactive/ impulsivity factors to provide DSM-IV diagnostic sub-types of ADHD groups including predominantly inattentive, predominantly hyperactive or combined types.

The scale has been used reliably to discriminate ADD with hyperactivity and without hyperactivity in addition to differentiating them from LD children and normal controls (Barkley, 1990).

To meet the DSM-IV criteria, four extra items were added (items 15, 16,17 and 18) to the scale to determine the presence and severity of ADHD symptoms addressed in criterion A1(f), A1(i), A2(e) and criterion C (see Appendix A).

2.3.3 Child Behaviour Checklist for Ages 4-18

The Child Behaviour Check-list (CBCL, Achenback & Edelbrock, 1983; Achenbach, 1991) is a 113 item multiaxial questionnaire yielding an 8 factor profile and includes Hyperactivity, Delinquent and Aggression which has been found to correlate highly with psychiatric diagnosis of ADHD and CD for six to 12 year olds (Edelbrock & Costello, 1988).

CBCL behaviour profiles on 60 ADHD children display elevated scores of the externalised factors (Hyperactivity, Aggression and Delinquency) of the scale (Edelbrock & Achenbach, 1980). The high scores on the Aggressive and Delinquency factor is expected due to the oppositional behaviour generally reported with ADHD and the high level of co-morbidity of ADHD with conduct problems (Barkley, 1990).

Interestingly, the CBCL behaviour profile also include elevated internalised scores on the obsessive and compulsive factor for ADHD children. Barkley (1990) argues that rather than reflecting the level of neuroticism in this clinical group the latter factor is more indicative of inattentive and hyperactive behaviours.

The CBCL has been found to discriminate effectively between children with and without a range of clinical disorders including ADD, Depression and Anxiety (Barkley, 1990). Current reliability of ADHD behaviour profiles have been established with other measures of ADHD including the Conner's Behaviour Checklist (Barkley et al., 1990). The test-retest reliability of the scales for behavioural problems have been reported at .95 (one week) and .59 for the stability of mother's rating after 6 months. Inter-rater agreement of child's behaviour between mothers and fathers was .98 for clinic referred children. Edelbrock and Achenbach (1980) report that there is a 95% agreement between clinicians and mother's rating of externalised behaviours in the 6 to 11 year old age range.

2.3.4 Vigilance Tasks

The vigilance tasks employed in this study were based on the Seidel Continuous Attention Test (SCAT; Seidel & Joschko, 1990). This computerised task presents a series of numbers from one to nine for 200 msec at a rate of 1.5 sec per stimuli. Each task consists of 800 stimulus presentations over a period of 20 min (40 events per minute). The target to non-target ratio is 6:40 (15% target probability) and targets were randomised across sets of 50 stimuli.

The target in the simple simultaneous task was '9' which was similar to that employed by Gordon (1986). In the complex successive vigilance task the target was any two repeated digits for example '5-5' or '2-2'. This variation on the SCAT reduced the priming effect of targets inherent in the A-X paradigm while maintaining similar information processing demands and memory load of the task.

2.4. Apparatus

A Toshiba T3100SX lap top computer (IBM compatible) equipped with a Thompson VGA colour monitor and a computer mouse was used to present stimuli and record CPT measures. Subject were seated directly in front of the monitor with the position of the mouse under their dominant hand.

2.5. Procedure

2.5.1 How the sample was selected

Prospective control subjects were randomly selected from different grades (Year 2 to Year 6, to access children between 7 and 11 years) of the participating schools. All parents of prospective subjects (n=140) were sent a letter with a brief description of the study before being asked to complete a consent form for their child to participate in the study (Appendix B and C).

On receipt of the consent forms (n=67) parents were sent out the CBCL and ADHD rating scale for completion and invited to contact the researcher if they had any questions or concerns regarding the information (Appendix D).

A total of 36 questionnaires of the 67 sent were returned completed. Two parents returned uncompleted questionnaires stating that the questions were 'too intrusive'. The return rate is in accordance with what would be expected from survey research (Ray & Ravizza, 1988).

All control subjects were assessed at their schools in a quiet room provided for the study. Each child was assessed during class time to reduce the possibility of competing playground noise and distractibility to subjects. All subjects were informed that their participation was voluntary and that they could withdraw at any time throughout the experiment.

The clinical subjects (n=19) were initially approached by a Paediatrician based on the presence of ADHD symptoms. Prospective parents of the clinical group were given basic information about the study and asked to complete a consent form and accompanying questionnaires (Appendix E and F). While a report was sent back to the referring Paediatrician, parents were informed that they would not be prejudiced in any way should they not want to participate in the study.

It was up to the parents to contact the Psychologist and make an appointment for their child. All clinical subjects were assessed at either a Doctor's surgery or in Professional rooms. Again, each subject was informed that they could withdraw from the study at any time. Every attempt was made to standardise the testing environments between locations and groups.

2.5.2 The Experimental Tasks

Each subject was tested individually. Testing sessions occurred between 8.30am and 2.30pm to attempt to maximise task concentration (Davies & Parasuraman, 1982). During testing children were assessed to obtain a pro-rated IQ using the verbal scale of the WISC-R (Information, Similarities, Vocabulary and Comprehension sub-tests). Subjects identified as having a pro-rated verbal IQ score of less than 80 were excluded from the study as this was outside the normal range of abilities.

At the start of the procedure subjects were seated 500mm in front of a computer monitor. Head position was not restrained although subjects were required to remain seated and to face the monitor during testing. The seat height was adjusted for each subject so that they could comfortably view and operate the computer. Shorter subjects were provided with a box at the base of their chair so that their feet were supported.

Subjects were asked to place their dominant hand on a computer mouse which was placed so that their arms were naturally bent to prevent fatigue. Each subject was instructed to press the button on the mouse to record his responses. More specifically, on the simple vigilance tasks, subjects were instructed to "...press the button every time every time they saw the number 9". On the complex task subject were instructed to "...press the button when they saw two numbers that were exactly the same, in a row, for example 2-2 or 5-5".

At the beginning of each task, subjects were given a practice session of one min (40 events) in which six targets were presented. During this time, performances were monitored to ensure that all targets were correctly identified. If subjects were unable to demonstrate competency during the initial practice session, additional practice was provided. Those subjects failing the second practice were excluded from the study.

The rate of stimulus presentation during the practice sessions was identical to test conditions, as not to affect

task performance (Davies & Parasuraman, 1982). Data from the practice sessions were not included in the analysis.

The experimenter was present throughout the testing period. Subject-experimenter interaction was kept to a minimum except when subjects physically orientated themselves away from the task. In this instance, subjects were instructed to "face the front and carefully watch the monitor for the numbers".

The order of presentation of the CPT tasks was counter balanced by presenting them in reverse order to alternate subjects. Verbal IQ assessments were conducted between the tasks to provide subjects with a break so as not to impede performance on the subsequent task.

Traditional CPT measures on the simple and complex tasks were recorded for each subject per block of 50 stimulus events and included:

a) percentage of correct hits (and conversely percentage of omissions).

b) percentage of commission errors.

c) response latency and variability of response times.

2.6. Analysis

SPSS for Windows was used to organise and analyse the experimental data. The 800 trials per task were summarised into 16 epochs of 50 trials each. Descriptive analysis were performed to determine the frequencies, means and standard deviations of groups on behavioural measures and

CPT scores across all 32 epochs (16 for simple and 16 for complex task).

Preliminary evaluation of the results lead to one child being excluded from the clinical group on the grounds that the estimated IQ score was below 80, suggesting Borderline Intellectual Functioning (APA, 1994, p.45). Further, four of the subjects referred by the Paediatrician failed to meet the clinical cut-off on the ADHD rating scales and were therefore included in the non-ADHD group. Similarly, two of the control subjects were found to have high clinical scores meeting DSM-IV criterion for ADHD and were included in the ADHD group.

A review of frequency data indicated that two of the normal control subjects failed to complete the complex task. These subjects missed 100% of the targets in 13 and 16 epochs respectively and were identified as outliers and removed from the following analysis.

The final number of subjects assessed in the study totalled 48. These subjects consisted of 16 with ADHD and 32 controls (non-ADHD). These subjects were compared on three separate CPT performance measures on simple and complex task of 16 epochs each using ANCOVAs.

Additional analyses was carried out using multiple and logistic regression on Genstat to evaluate the significance of ADHD diagnosis in predicting CPT performance relative to CD.

CHAPTER 3: Results

3.1. Raw Data

The raw scores comprising of Reaction Times (RT), percentage of correct responses (Hits) and percentage of inappropriate responses (Commission Errors) generated by the CPTs were averaged for each epoch (50 trials each) and are presented in Appendix G. ADHD ratings of Inattention and Impulsivity, pro-rated WISC-R scores and CBCL scores (Hyperactivity, Aggression and Delinquency) are also provided in Appendix G for each group.

Analyses of the descriptive data and the ANOVA group comparisons were conducted using SPSS for Windows on an IBM compatible personal computer. ANCOVAs were also performed using SPSS. Logistic regression analyses of Hits and Commission Errors and multiple regression analyses of RT were conducted using GENSTAT on a UNIX computer.

The results of these analyses are presented in four parts. The first reviews the differences between the groups on ADHD rating scale to assess the validity of the group classifications. The second part compared the CPT performances of the two groups. ANCOVAs were conducted for each of the CPT measures using age and IQ as covariates. The third part of the analyses evaluates the concurrent validity of the CPT measures as a indices of sustained attention, by assessing the relationship between these measures and the ADHD indices of inattention and impulsivity. Finally, regression modelling was used to examine the unique contribution of the ADHD diagnosis in

predicting CPT performance after excluding the effects of coexisting CD.

3.2. Validity of the group classification.

Means and standard deviations of IQ, age(months), CBCL scores (hyperactivity, aggression and delinquency) and vigilance measures are presented in Table 3.1. The scores for Impulsivity and Inattention are expressed as z scores calculated relative to the published norms (DuPaul, 1990).

Table 3.1. Mean scores for ADHD and Control Groups on measure of IQ, AGE , ADHD rating,and CBCL scores

	ADHD	(N=16)	Control	(N=29)	Total	(N=45)
	Mean	s.d	mean	s.d	mean	s.d
age(mths)	111.26	13.22	115.12	17.35	113.87	16.02
IQ	103.00	14.20	104.40	12.80	104.00	13.20
Inattention	1.69	0.69	-0.24	0.12	0.40	0.16
Impusivity	1.56	0.22	-0.38	0.13	0.27	0.17
Hyperactivity*	77.1	9.7	58.2	6.3	64.5	11.4
Aggression*	76.0	10.9	61.3	10.1	66.2	12.5
Delinquency*	73.9	8.2	59.8	6.9	64.5	9.9

*p=<.05

One way ANOVAs were performed to evaluate differences between the groups. There were no significant differences between the groups on age (months) or IQ ($F(1)=.087$, $p>.05$ and $F(1)=.125$, $p>.05$ respectively). Nevertheless, given the documented effects of age and IQ on vigilance performance, these variables were used as co-variates in the remaining analyses to increase their statistical power.

The group comparisons for the ADHD and CBCL behavioural scales showed that ADHD subjects were significantly higher than Controls on mean scores of Inattention ($F(1)=104.961$, $p<.001$), Impulsivity

(F(1)=66.457, p<.001), Hyperactivity (F(1)=77.703, p<.001) as would be expected. In addition, the group differed substantially on mean measures of Aggression (F(1)=21.419, p<.001) and Delinquency (f(1)=39.713, p<.001).

Figure 3.1. (Appendix H) shows the distribution of scores for the behavioural measures in the form of box plots. As expected, the scores on Impulsivity and Inattention discretely define the groups on these measures. However, there was an appreciable overlap between the groups on CBCL scores (Aggression, Delinquency and Hyperactivity). Fifteen of the 16 ADHD subjects were in or above the clinical range on the Aggression and Delinquency factors and were judged to have co-existing CD. A total of nine out of 36 control subjects were found to have CD scores in the clinical range.

Correlations calculated across the full sample between the ADHD rating scale and CBCL show a strong relationships between CD variables and ADHD ratings. The Aggression and Delinquency ratings correlated positively with Inattention (r=.69, p=<.05; r=.78, p=<.05) and Impulsivity (r=.77, p=<.05; r=.77, p=<.05) respectively. The correlation between ADHD and CD implies a confounding between these measures, so that the Clinical group differed form the Controls not only on the critical measures but also in rated conduct problems.

Due to the small sample sizes, it was not possible to separate ADHD subgroups with high and low CD scores. An attempt was therefore made to separate the effects of ADHD

and CD on CPT performance by using logistic regression. This is presented in Section 3.4.

3.3 Effects of ADHD diagnosis on CPT Performance.

Three of the normal control subjects failed to complete the Complex task. Of these, two missed 100% of the targets in 13 of the 16 epochs and the other missed 100% of 9 epochs. These subjects were rejected as outliers. The final experimental groups consisted of 16 ADHD and 29 control subjects.

Figure 3.2 presents mean performance (Reaction Time, Percentage of Correct Hit and Percentage of Commission Errors) for each epoch of the Simple and Complex CPT tasks for the two experimental groups. Overall, the graphs show similar trends in performance in the two groups, however ADHD group showed greater variability over time.
Table 3.2 presents the mean CPT scores for Clinical and Control groups on Simple and Complex tasks averaged across epochs. These were analysed by Group x Task x Time split-plot ANCOVAs (with IQ and Age as covariates). There appeared to be a non-homogeneity of the group variance on measures of Hits and Errors with the variance for the ADHD group almost tripling between the Simple to Complex tasks). To stabilise the variance within groups these scores were subjected to arcsin transformations before analysing the data (Winer, 1971). The full analyses are presented in Tables 3.3 - 3.5 (Appendix I).

a)

b)

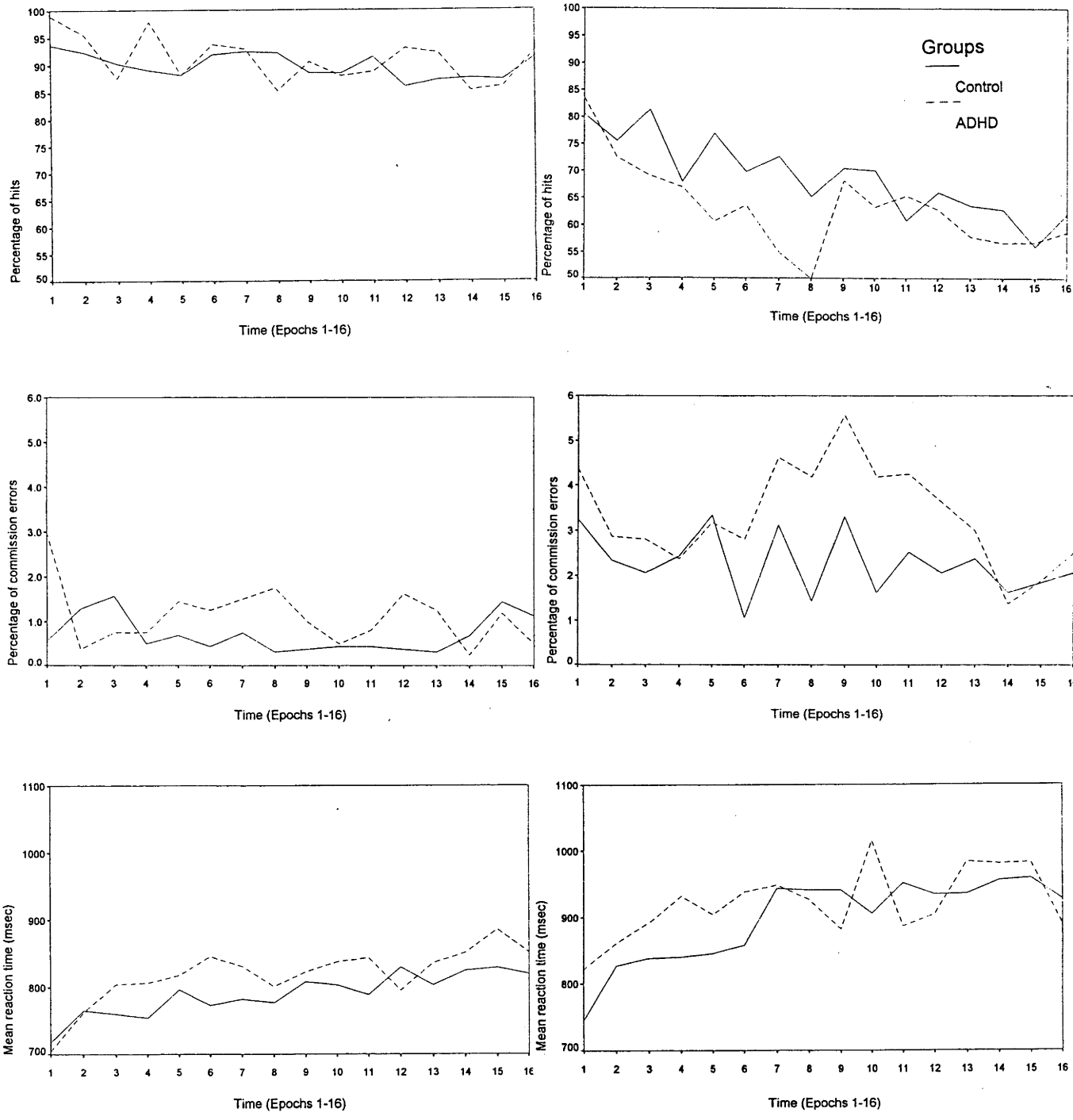

Figure 3.2 Changes in performance over time for ADHD and Control subjects on Simple (column a) and Complex (column b) tasks for Hits, Errors and RT.

Table 3.2 Mean performance scores for ADHD and Controls on Simple and Complex tasks

	ADHD	(N=16)	Control	(N=29)	Total	(N=45)
	Mean	s.d	Mean	s.d	Mean	s.d
Simple						
RT	818.72	124.78	779.33	115.69	792.46	118.95
%Hits	91.02	6.58	89.89	12.80	90.27	11.05
%Error	1.12	1.08	0.71	0.99	0.84	1.03
Complex						
RT	893.88	115.87	876.03	115.12	881.98	114.45
%Hit	63.07	20.04	70.03	17.74	67.84	18.66
%Error	3.35	3.39	2.34	1.49	2.68	2.33

As expected, Age had a significant effect on CPT performance. That is older subjects performed better than younger subjects overall. IQ was significantly related to Commission Errors but to no other variables. A negative correlation between IQ and Error rate indicates that children with higher IQs produced fewer Commission Errors than those with low IQs.

There were significant main effects for time and task on all measures of performance. Performance changed significantly as a function of time spent on task as measured by RT, Hits and Errors. However, no simple trend is evident. Similarly, performance on Complex tasks was significantly worse than performance on Simple tasks, but this difference was not great.

There were significant Time x Task interactions on measures of Hits and Errors but not RT. The deterioration in accuracy of response over sessions was greater for the more Complex task. The non-significant Time x Task interaction for RT indicates however that both Simple and Complex tasks showed the same slowing of responses.

The main interest of this study was in group differences. No significant main effects were found for Group on CPT performance, and in general there were no significant interactions including Group. While there was some weak evidence for a Group x Time interaction for Commission Errors ($F=1.72$, $df=15$, $p=.043$), this might be attributed to a Type 1 error resulting from multiple testing. This interaction may not be significant if a Bonferroni criterion were applied.

Figure 3.2 shows that if a Time x Group interaction did exit for Commission Error, it would be a complex one - involving a deterioration in performance in the middle epochs of the experiment for the ADHD children but not for the controls.

In summary, there was little evidence of differences between the groups on CPT measures. There was evidence of a decrement in performance over time and evidence that this decrement increased with increasing task complexity. But the ADHD group did not demonstrate convincing evidence of worse performance than the Controls.

3.4 Concurrent Validity of CPT as a Measure of Attention

To assess the concurrent validity of the task variable as a measure of inattention, correlations between CPT indices and behavioural measures of ADHD were examined. Overall, these measures were not statistically significant broardly confirming conclusions based on the group comparisons in Section 3.3. An exception is provided by

the RT in the simple task. Low positive correlations were found between simple RT and ADHD ratings of inattention and impulsivity ($r=.313$, $p=<.05$ and $r=.308$, $p=<.05$, respectively). While this latter finding may be interpreted as a Type 1 error, these correlations provide a more sensitive measure of the relationship between these variables.

Commission Errors did not correlate with behavioural measures of Impulsivity (as measured by the ADHD rating scale) or CBCL Hyperactivity rating on either the Simple or Complex tasks. Similarly, percentage of Hits were not found to correlate to ADHD measures of Inattention.

3.5 Evaluation of the relationship between subject variables and overall performance on CPT tasks.

As pointed out in Section 3.1, there is considerable comorbidity between CD and ADHD in the ADHD group. Additionally, CD was substantially present in the Control group. This raises two problems for this study. The first is that if any group effects had been found in the group comparisons reported in the preceding section the effects of ADHD would have been confounded with any effects of CD on CPT performance. The second point is that any effects of CD on CPT performance would have been attenuated by a group overlap of this measure.

In order to assess any independent effects of ADHD and CD a logistic regression analysis (Tabachnick & Fidel, 1996) was conducted using subjects' scores aggregated

across epochs for each measure. To determine the best model of prediction four models were tested. The first model simply tested if there were any effects for group membership on performance. The second model tested whether there was any group effect after adjusting for age and IQ as these are known to confound CPT results. The third model tested for group effects after adjusting for age, IQ and CD (using CBCL Aggression and Delinquency scores). The fourth and final model assessed which of the variables best accounted for CPT performance using a backward elimination process in which the effects of the other variables are taken into account.

A summary of the results for the four models are presented in Table 3.6. No significant effects were found for group membership based on ADHD diagnosis (Model 1). That is ADHD was not significant in predicting overall CPT performance scores on either task. Similarly, an assessment of Model 2 failed to find any significant effects for ADHD after adjusting for Age and IQ. This latter finding is consistent with the ANCOVA analyses.

Model 3 also failed to find any significant effect for ADHD after adjusting for CD, Age and IQ. That is there were no independent effects for ADHD in predicting CPT performance on any of the measures. Estimates of the coefficients for CPT scores for Model 3 are shown in Tables 3.7 to 3.10.

Table 3.6. Summary of accumulated analysis of deviance for logistic and multiple regression for models of prediction of CPT performance

	Model 1	Model 2	Model 3	Model 4
Simple task				
Errors	p=.131	p=.167	p=.265	+Age+IQ
Hits	p=.825	p=.459	p=.087	+Age
RT	p=.158	p=.444	p=.680	+Age
Complex tasks				
Errors	p=.582	p=.533	p=.691	+Age
Hits	p=.073	p=.296	p=.343	+Age+Aggr+Del
RT	p=.727	p=.678	p=.635	+Age

Estimates of regression coefficients for Hits and Commission Errors on Simple tasks are presented in Table 3.7. As expected, in the full model Age and IQ had a significant effect on Commission Error ($p = <.05$). Negative coefficients on these measures indicate that older children and children with higher IQs made fewer errors. No significant effect was found for ADHD or CD.

Table 3.7 Logistic Regression Estimates of Coefficients of Predictor variables for hits and errors on the Simple Task

CPT measure	Predictor	Estimate	s.error	t(42)
Errors	Constant	0.370	1.950	0.19
	Age	-0.262	0.121	-2.16*
	IQ	0.025	0.010	-2.76*
	Aggression	-0.028	0.076	-1.01
	Delinquency	0.024	0.037	0.65
	ADHD	0.482	0.426	1.13
Hits	Constant	-2.321	1.960	-1.18
	Age	0.661	0.135	4.91*
	IQ	0.004	0.010	0.39
	Aggression	0.023	0.024	0.96
	Delinquency	-0.056	0.032	-1.73
	ADHD	0.661	0.382	1.73

*p=< .05

Similarly, older children had a higher level of Hits than younger children. No significant effect was found for IQ, CD or ADHD diagnosis. However, there is evidence of a positive relationship between ADHD and proportion of hits

(after adjusting for the other variables) suggesting that ADHD children tend to have a higher number of Hits overall.

Table 3.8 Estimate of Regression Coefficients of Predictor variables for CPT measures on the Complex Task

CPT measure	Predictor	Estimate	s.error	t(42)
Errors	Constant	-1.79	1.390	-1.29
	Age	-0.157	0.758	-2.07*
	IQ	-0.005	0.007	-0.74
	Aggression	-0.008	0.176	-0.47
	Delinquency	0.009	0.026	0.39
	ADHD	0.108	0.271	0.40
Hits	Constant	-3.91	1.790	-2.19*
	Age	0.333	0.093	3.57*
	IQ	0.014	0.009	1.55
	Aggression	0.042	0.022	1.91
	Delinquency	-0.039	0.030	-1.31
	ADHD	-0.318	0.332	-0.96

*p< .05

Table 3.8 summarises logistic regression estimates for Hits and Error rate on the Complex task. A significant effect was found for age on both measures. Older subjects made significantly less errors and more correct responses than younger subjects. This supports the developmental hypothesis for CPT performance. No significant effect was found for any other measure on this task (IQ, CD or ADHD).

Speed of response data was assessed using multiple regression. Coefficients for RT represent the strength of the predictive relationship between the criterion and independent variables. These estimates are presented in Table 3.8.

Table 3.9. shows a significant negative effect of Age on RT (p=<.05). Younger subjects tended to have longer response times than older subjects. No significant effect was found for IQ, CD or ADHD for speed of response.

Table 3.9. Multiple Regression for Reaction Time on Simple CPT

	Predictor	Estimate	s.error	t(42)
React.Time	Constant	1313.00	232.0	5.65*
	Age	-40.7	11.40	-3.56*
	IQ	-1.67	1.19	-1.41
	Aggression	-1.24	2.89	-0.43
	Delinquency	1.73	4.14	0.42
	ADHD	18.31	44.20	0.14

*p=<.05

Regression analysis for reaction time on Complex tasks failed to find any significant effect for any of the predictor variables. Table 3.10 present regression coefficients for each of these variables. There were no significant findings on any of these variables.

Table 3.10. Regression coefficients for Reaction Time for Complex Task

Criterion	Predictor	Estimate	s.error	t(42)
React.Time	Constant	1182.00	264.0	4.48*
	Age	-13.90	13.0	-1.07
	IQ	-1.34	1.35	-0.99
	Aggression	2.42	3.29	0.74
	Delinquency	-3.20	4.71	-0.68
	ADHD	24.00	50.20	0.48

Using a backward elimination process the various variables were assessed to determine the best model for predicting CPT performance (Model 4). A summary of the results for this stepwise equation is presented in Table 3.6. As expected, Age significantly contributed to the variance in performance on most of the measures. Age and IQ were the best predictors of Commission Error on the Simple task but not the Complex task. IQ did not contribute significantly to any other measure.

However Age and CD were found to best predict the number of Hits on the Complex task but not the Simple task.

ADHD did not add to the model in predicting performance on any measure. CD rather than ADHD was found to account for the variance in performance on the measure of attention (Hits) on the Complex task.

CHAPTER 4: Discussion

4.1. Overview

The main aim of this study was to compare ADHD subjects with a group of normal controls on tasks requiring sustained attention. Both Simple and Complex CPT tasks were employed to assess the effects of time and information processing load on attention in ADHD subjects. It was expected that if ADHD subjects had deficits in their ability to sustain attention, they would show a greater decrement in performance as time and complexity of task increased relative to controls, independent of age, intelligence and CD.

The ADHD subjects in this study were found to be significantly higher than Controls on measures of Inattention, Impulsivity and Hyperactivity and met the DSM-IV criteria for ADD and ADHD. However, the Clinical group was also found to score high on Aggression and Delinquency measures indicating a high level of co-morbid CD. This latter finding was surprising given the selection criteria of the subjects employed but tend to support earlier findings of high concordance of these two disorders (Barkley et al., 1990; Prior & Sanson, 1986; Sabatino & Vance, 1994) . The ADHD and CD factors were so highly correlated that it was difficult to examine the independent effects of these disorders on performance.

It was expected that in order to provide concurrent validity to CPT measures of sustained attention, that measures of Hits, Errors and RT would be positively

correlated with ADHD scores of Inattention, Impulsivity and Hyperactivity. This was not the case. Evaluation of the relationship between behavioural measure of ADHD and CPT scores failed to find any significant correlations. This was unexpected and raises a number of questions regarding the concurrent validity of CPT as a measure of sustained attention.

Overall, the results did not support the central hypotheses of the study. While subjects were found to show a significant decrement in performance as time and complexity of tasks increased, there was no strong evidence to suggest the decrement in ADHD performance was any greater than Controls on these measures. These findings were not consistent with previous studies (Barkley et al., 1992; Grodzinsky & Diamond, 1991; Klee & Garfinkel, 1983; Seidel & Joschko, 1990) and raise a number of questions in regards to the high level of co-morbidity between CD and ADHD; validity of the ADHD diagnosis and its primary symptoms of inattention and the utility of CPT in ADHD research.

4.2. The Results in Relation to the Experimental Hypotheses

In order to directly assess Information Processing theories of ADHD, it was predicted that ADHD subjects would show a greater decrement in performance over time and that this would be greater on Complex tasks than Simple CPT compared to the Controls. This hypothesis was not supported.

A significant interaction was found between Time and Task for all measures. Both ADHD and Control subjects were found to have lower Hits, increased Commission Errors and slower RT on the more Complex tasks as Time on Task increased. This finding supports the thesis that task demands in the Complex task were greater than in the Simple task. However, failure to find the three way interaction for Group x Task x Time indicated that ADHD subjects did not have a greater problem with the increased information processing demands than Controls. Results did not support the hypothesis that ADHD subjects have difficulties allocating resources to tasks requiring more effort.

Similarly, the results did not support the stimulation model of ADHD which predicted that ADHD subjects would 'fatigue' faster than controls across both tasks at similar rates. There was no evidence of group differences across tasks. That is, independent of information processing load and duration of time on task, ADHD performed just as well as controls, failing to support the notion that ADHD subjects have difficulties regulating arousal or alertness as Time on Tasks increased.

The non-significant effects for group membership on CPT scores suggest that behavioural measures of inattention and CPT performance are independent. In order to provide concurrent validity to the CPT task as a measure of sustained attention, it was expected that these measures would correlate with the behavioural measures. However, there were no significant relationships between behavioural

measures of Inattention, Impulsivity and Hyperactivity and the CPT indices (with the possible exception of the RT on the Simple task).

Moderate positive correlations were found between Simple RT and ADHD measures of Inattention and Impulsivity. Children who scored higher on measures of Inattention and Impulsivity recorded longer response times. These results are difficult to interpret. While RT measures speed of response and may provide an assessment of preparedness to respond, it incorporates both the decision time and the motor response time (Parasuraman & Davies, 1984).

Children who scored high on Inattention measures were not expected to respond with shorter RT as they would not have been attending to the targets as they presented. Children who scored high on the Impulsive measures were expected to respond faster as they were more likely to make a response whether targets were presented or not. Longer RT for these subjects may represent longer decision times rather that motor response times as Impulsive children may have problems determining when, rather than if, to make a response.

The second aim of this study was to evaluate the effects of Age and IQ on measures of sustained attention. To assess Maturational theories it was predicted that ADHD would lag behind their control counterparts in their ability to sustain attention. This hypothesis was not supported.

Age was the best predictor of subjects' performance on most of the measures of sustained attention. Results demonstrate that age had a significant independent effect on all indices on the Simple CPT and for number of Errors on the Complex task. There was also some evidence of age effects on RT on the Complex task. These findings support the thesis that children tend to perform better as their age increases. However, there was no evidence that ADHD children lag behind control subjects on CPT measures.

The limited numbers of subjects in this sample did not permit direct comparisons of subjects with and without ADHD within different age groups. While there was partial evidence of a developmental trend in performance on CPT tasks, with younger subjects performing worse than older subjects, this finding was not unique to those subjects diagnosed with ADHD.

The effects of IQ were mixed. No significant effects for IQ were found across tasks for RT or percentages of Hits. Regression analyses demonstrated a significant effect for IQ on Commission Error for the Simple task with higher IQ subjects making fewer errors than subjects with low IQs. Interestingly, there was no effect for IQ on the Complex task. One possible explanation for this finding is that subjects with low IQ's may respond more randomly than high IQ children as the demands of the simple task are beyond their capacity to attend. The lack of significant finding on the Complex task implies that both groups found

the task equally difficult which may reflect a ceiling in performance for the children with high IQs.

The high level of CD in the ADHD subjects in this sample made it difficult to determine the unique effects of ADHD on CPT performance. Even if the ANCOVA results showed differences between the groups it would have been difficult to attribute the difference in performance to ADHD alone. In order to assess the best model for predicting CPT performance, Logistic regressions were conducted to evaluate the independent contribution of age, IQ, CD and ADHD on CPT scores.

There was some evidence that ADHD diagnosis had an effect on predicting the number of Commission Errors on the Simple task and that this trend was further evident after adjusting for the confounding variables. However, ADHD diagnosis did not significantly add to the regression model on any other performance measure. That is, after adjusting for age, IQ and CD, ADHD diagnosis had no effect on number of Hits, RT or Commission Errors on the Complex task.

Interestingly, measures of Delinquency and Aggression factors were found to significantly add to the model in predicting scores of Simple and Complex Hits and Simple Commission Error (after controlling for the effects of Age and IQ). While the independent contribution of CD was not directly assessed in this study, children with high levels of Aggression and Delinquency tended to have lower hit rate overall and a higher proportion of Commission Errors for Simple CPT.

This finding was surprising. Clinical subjects employed in the study were specifically referred for inattentive, impulsive and hyperactive behaviours, not for oppositional or conduct problems. Those subjects who were high on CD score performed worse on the experimental measures of inattention and impulsivity as measured by the CPT (Hits and Commission Errors), independent of their scores on the behavioural rating scales used to identify these symptoms of ADHD.

While the significant positive correlation between Inattentive, Impulsive, Hyperactive, Delinquent and Aggressive behaviours appears to support the argument that ADHD and CD are positively related the stepwise regression analysis did not support the idea of these disorders being on a continuum of severity. That is, if this were the case, both ADHD and CD would have been the best predictors of CPT performance after adjusting for Age and IQ. However, ADHD was not significant in predicting task performance and the significant effect for CD was independent of ADHD scores.

The results did not demonstrate any strong evidence of differences between ADHD and Controls on measures of sustained attention. While there was a Group effect noted for ADHD on percentage of Commission Errors on the Simple task (ANOVA), further analysis using regression model indicated that this difference was attributed to high levels of CD not ADHD per se. After adjusting for the confounding variables of Age, IQ and CD, the diagnosis of ADHD was not significant in predicting performance on any

CPT measure. These findings contradict those of several earlier studies and have a number of implications regarding the measures employed to assess ADHD and sustained attention using CPT tasks.

4.3. Results in Relation to Previous Studies.

In view of the findings from the existing literature the results of this study were unexpected. Earlier studies have reported that ADHD children show a faster rate of decline in performance than controls as time on tasks increase. Similarly, ADHD children have been found to show a greater decrement in performance on more demanding tasks with a greater information processing load (Sykes et al., 1973; Seidal & Joschko, 1990). While there are some studies that have not found differences between ADHD and controls on CPT, these have not specifically assessed the effects of time and complexity on task performance.

There were a number of differences between the present study and previous studies, which may account for the different results. These variables are further discussed in terms of the specific differences between this study and others in assessing the effects of ADHD on CPT performance.

Sykes et al. (1973) and Siedel and Joschko (1990) reported differences in the detection rate and RT of ADHD subjects compared to controls. However, in the present study ADHD subjects did not differ in their ability to detect targets or speed of response over the duration of the task. While the clinical group was found to have a

higher rate of Commission Errors as time on tasks increased they did not differ on any other measure. Further, unlike Sykes et al. there was no evidence that ADHD subjects had a higher performance decrement on Complex than Simple tasks relative to controls.

While the Complex successive task employed in this study differed from previous research, it was expected that subjects would find this task more demanding. That is, the successive tasks employed by Sykes et al. (1973) and Seidel and Joschko, (1990), consisted of targets proceeded by a warning stimulus (i.e. A-X paradigm) priming subjects when to make a response. Given the random nature of the target presentation in this study (where potentially any event could proceed a target) subjects were required to maintain vigilance throughout the entire task. This made the task more difficult than in other studies where subjects responded to a fixed target prefix.

Another significant difference between Seidel and Joschko's study and the present investigation is that target to stimuli ratio was more frequent in the former (1:6.7 compared to 1:15 respectively). The higher target to stimulus ratio was expected to place higher demands on the subjects as they were more likely to become bored (Power, 1992). In addition, the tasks in this study had 200 events more than those employed by Seidel and Joschko and subjects were required to attend for approximately five minutes longer.

One possible explanation for the difference in results in the present study compared to previous studies is that the Complex task employed here was too difficult for subjects. The increased attentional demands and time of the task may have caused subjects to perform poorly on these measures. Rather than obtaining a performance ceiling on tasks, the lower level of performance may represent a base-line for the groups in which there is no detectable difference in performance. The highly significant Task x Time interaction for the CPT measure provides some tentative support for this argument as all subjects performed worse on the Complex task. Whether subjects' performance was affected by adopting a different response strategy that was less effective, or a decrease in motivation on these tasks is unclear.

If it is assumed that subjects change their strategies for responding on more challenging tasks, they would respond more randomly, increasing the rate of correct and incorrect responses (Douglas, 1983; Sergeant & Scholten, 1985(a), 1985(b); Tomporowski & Simpson, 1990). This was not the case. While subjects did have a higher rate of Commission Errors on the Complex task, they had fewer Hits. However, the longer RT on more complex tasks suggest that even though subjects were making more Errors, they appeared less certain about their responses, as they were taking longer to respond.

Alternatively, the increased RT could simply reflect low levels of autonomic arousal which would have made it

more difficult to maintain high levels of motivation on these complex tasks. As subjects approached the end of a set they tended to be more unsettled and often asked questions about how long it would be to the end. This anecdotal evidence supports the idea that motivation rather than changes in response strategies were responsible for differences in performance as the complexity of the task increased.

Another difference in the administration of the task from Sykes et al. (1973) was that in this study the experimenter was present during testing. While the experimenters in this study attempted to be as unobtrusive as possible, sitting peripherally to subjects, it is likely that ADHD children were positively affected by their presence.

Several studies have shown that ADHD subjects tend to perform better on CPT tasks in the presence of the experimenter (Power, 1992; Corkum & Siegel, 1993; Fischer, et al., 1995). Studies by Draeger et al. (1986) found that ADHD subjects only performed worse than controls when the experimenter was absent. Studies such as these support the idea that ADHD is a performance deficit rather than a deficit in sustained attention (Barkley, 1994).

This study, like that of Draeger et al. (1986) employed ADHD subjects who had a high level of co-morbid CD and therefore may not have represented a pure ADHD group. Fischer et al. (1995) found that ADHD subjects with high levels of CD were less likely to be detected on CPT

performance. Similarly, Haperlin et al. (1990) found that ADHD children with co-morbid CD performed more normally than ADHD children without CD.

It is possible that the combination of experimenter's presence and subjects' high levels of CD in this current study may have interacted to normalise ADHD subjects' performance. Subjects with CD may be more sensitive to experimenters' presence than those with ADHD without CD. That is, children with high levels of oppositional behaviour or CD may be more able to regulate their behaviour than those with ADHD and choose not to in the absence of supervision.

Compared to Sykes et al. (1973) and Seidel and Joschko (1990), the subjects in this study were approximately one year older. Previous studies employing subjects with a mean age of more than nine have been less likely to demonstrate differences between ADHD and normal control on CPTs (Corkum & Siegel, 1993). Since children's ability to attend changes between the ages of eight and nine years of age (Chelune et al., 1986; Barkley et al., 1990), it is possible that the older subjects in this group reflect those who have less marked attentional problems, but continue to deviate from the norm on conduct behaviours (Gittelman et al., 1985).

The failure to demonstrate a relationship between CBCL parent ratings of ADHD behaviours and CPT performance was unexpected and raises concerns regarding the validity of CPT as a measure of attention. While this study is not

alone in finding non-significant correlations between CPT Hits, Errors and RT and behavioural measures of Inattention, Impulsivity and Hyperactivity (respectively) (Lovejoy & Rusmussen, 1990; Seidel & Joschko, 1990), the results differed from a number of other studies (Klee & Garfinkel, 1983; Gordon, 1988; Grant et al., 1990).

Those studies reporting high concurrent validity for CPT measures based on behavioural measures of inattention differ from this study in several ways. For example, Klee and Garfinkel (1983) employed ADHD subjects from a psychiatric population in which co-morbid diagnoses were not controlled for. In a number of other studies, subject and contextual variables (e.g. age, IQ, experimenters' presence) known to affect CPT performance were not taken into account in the assessment or analyses of their results (Douglas, 1983; Draeger et al., 1986; Gordon, 1988; Grant, et al., 1990; Corkum & Siegal, 1993; Barkley, 1994). Similarly, studies using teacher ratings rather than parent ratings of ADHD behaviours were more likely to find correlations with test results (Gordon, 1988; Barkley, 1994).

This study attempted to control for some of the main variables known to affect performance on measures of sustained attention. The clinical group was also defined by current diagnostic criteria which is more stringent than those employed in earlier studies. While these changes were expected to assess ADHD performance on CPTs better,

they have minimised the difference between ADHD subjects and controls as found in previous studies.

4.4. Implications of the Present Study

The lack of a significant difference in this study of ADHD performance on tasks of sustained attention compared to controls has a number of theoretical implications. Firstly, these findings raise doubts about the empirical validity of DSM-IV criteria for ADHD as measured by key tasks. The core feature of attentional deficits in this clinical group could not be established. In order to empirically validate the criterion of inattention, subjects with ADHD would be expected to show a deficit in sustained attention.

The clinical subjects used in this sample were referred by a Paediatrician for inattentive, hyperactive and impulsive behaviours and scores on ADHD rating scales and CBCL found that the clinical group were significantly higher on these symptoms than the control group. However, in this study the clinical group also had significantly higher scores on the Aggression and Delinquency factors of the CBCL. This unexpected finding suggests that the CD scores on the CBCL may have been inflated due to cultural differences in Australian boys compared with those in the US in which the norms have been scored.

High positive correlation between measures of ADHD and these conduct scores question the independence of these diagnostic criteria. It has been documented by other

researchers that there is a high concordance rate (up to 80 percent) between ADHD and CD (Robins, 1992; Barkley, 1994). The high level of co-morbid CD in the clinical group further questions the validity of the ADHD criteria as they are unable to identify a unique pattern of behaviour/symptomatology, course or response to treatment (Robins, 1992).

Some authors have conceptualised CD as a progression of impulsive, hyperactive behaviours and argued that ADHD subjects with co-morbid CD represent a more dysfunctional sub-type of ADHD (Barkley et al., 1990). However, others have argued that as ADHD children get older they simply tend to display fewer problems of attention and more conduct problems (Chelune et al., 1986).

This alternative conceptualisation of the disorder suggests that ADHD may progress to CD in some cases and that we would not necessarily expect an attention deficit per se in the older sample. While there is a consistent and well documented relationship between ADHD and CD, the specific parameters of the relationship have not been clearly established.

If we assume that the older ADHD group in the present study reflects those that have progressed to CD, then the significant effect found for CD on CPT could be interpreted as subjects diagnosed as ADHD performing worse on these measures. However, this explanation of the data is difficult to accept as it would have been expected that

ADHD would add to CD in predicting performance on CPT tasks and this was not supported by the analyses.

One of the main difficulties in diagnosing ADHD is that behaviours need to be 'outside normal range'. This criterion appears to assume that the behavioural constructs being assessed are both definable and that a quantitative criterion of normality is available. Determining what is 'normal' for each age group is essential in arriving at a diagnosis.

The use of the CBCL in this study raises some questions regarding the need for age specific norms as suggested by Barkley (1990). While the ADHD subjects employed here were in or above the clinical range for Hyperactivity and were high on ADHD rating scales of Inattention, Impulsive, it is unclear whether they differed significantly from children of different age groups. The grouped norms on the CBCL factors range from four to 12 years and do not offer specific norms for boys aged nine as opposed to those aged seven. Therefore, arriving at a diagnosis based on the criterion 'age appropriate' is difficult since the norms are not age specific and do not give mental age equivalents.

Similarly, diagnosis of CD is also dependent on criteria assuming age appropriate norms. The use of norms based on wide aged bands could tend to result in older children being mis-diagnosed. Older children tend to display higher levels of aggression, truancy, smoking, etc., compared to younger children. Identifying behaviours

that are considered excessive for each age group may facilitate more accurate diagnosis for CD.

The validity of CPT tasks as a measure of sustained attention also needs question. Earlier studies were able to demonstrate a relationship between the behaviour measures of inattention and CPT tasks providing concurrent validity to these tasks (Glee & Garfinkel, 1983; Gordon, 1988; Barkley, 1994). CPT measures have been found to correlate with other psychological measures of attention for example PASAT, WCST and Distractibility factor on WISC-R (Barkley et al., 1992). However, these studies did not clearly define the constructs underlying CPT or adequately control for CD and other subject variables known to influence performance. When these confounding variables are taken into account, the relationship between CPT indices and behavioural measures of Inattention, Impulsivity and Hyperactivity are reduced.

The validity of CPT tasks in assessing ADHD is important in the clinical setting. Most of the literature advocating the use of stimulant medication cites improvement in performance on these tasks. However, if ADHD subjects do not have any baseline differences on CPT tasks, it is difficult to demonstrate a normalised performance post-medication. The improvement in CPT performance following stimulant treatment is not specific to ADHD as all children on stimulant medication perform better on these tasks following medication. More valid

measures are needed in order to determine the efficacy of these medications in clinical practice.

Further, CPTs in its various forms are commercially available as a screening tool for ADHD. While several studies have demonstrated its ineffectiveness in distinguishing between ADHD children and controls, the test is being more accepted as part of clinical test batteries. The results of this study suggest more caution is required. Further research identifying the underlying constructs being measured by these tasks is needed. It is unlikely that any one assessment tool will definitively identify subjects with ADHD. For now, it is important that clinicians continue to use all the available resources in reaching a diagnosis of ADHD and in identifying its associated deficits.

4.5. Limitations of the Current Study.

While this study attempted to control for several of the variables known to affect CPT performance and clinical assessment of ADHD, there are a number of limitations that could have impacted on the reliability of these results. While some of these limitations are not specific to this study they pose further questions regarding the constructs underlying the disorder and tasks being assessed.

Firstly, the clinical scales used to assess the presence of ADHD and CD symptoms are problematic. There are updated versions of the ADHD rating scale that include the additional criteria of the DSM-IV, but these have been

based on adult norms (Barkley, 1995) and are not suitable for the younger age range. The ADHD rating scale employed in this study was an adaptation of DuPaul's (1990) and included the additional DSM-IV criteria. Behaviours were normed on existing data for the 14 items from the original scale and then marked for the presence or absence of symptoms on the additional criteria. These new items were not normed. The severity of the symptoms on these latter items could not be assessed, and it is difficult to determine therefore, whether they were in the clinical range for a positive diagnosis of ADHD.

The norms used for assessing ADHD and CD scores were based on an American population. Achenbach, et al. (1990) found that while Australian scores on these behavioural measures significantly correlated with American norms, Australians tend on average to score higher. Using American normed tests such as the ADHD rating scale and CBCL in an Australian population could have increased the risk of making a false positive diagnosis for ADHD and CD.

A second limitation of the current study, and perhaps the most important, is the small number of subjects tested. This small sample makes it difficult to generalise the results to the broader clinical population of ADHD subjects. While this study was restricted to a specific time frame for recruitment and assessment of subjects, it highlighted several problems with identifying and recruiting ADHD subjects for testing.

Some of the clinical subjects referred for assessment failed to meet the DSM-IV diagnosis based on symptom criteria and low IQ scores, further reducing the number of clinical subjects assessed. In addition, it was difficult to access a subject group that had not already been medicated. Response to stimulant medication has often been a way of confirming ADHD diagnosis. Therefore, most of the children diagnosed with ADHD in the community were already receiving medication and automatically excluded from the study.

Thirdly, the primary use of parental questionnaires to determine ADHD diagnosis is also problematic. ADHD children who were referred for assessment were subsequently trialed on medication. Parents of ADHD children may be more likely to overstate problems than those of normal controls. Referral to a Paediatrician would have been the final, rather than the first port of call for assessment. Parents are often referred to a Paediatric specialist with the expectation that their child will be trialed on medication and are more likely to have to 'prove' their case. Therefore, it is difficult to assess the reliability of parents rating of ADHD behaviours when the parents may directly benefit from a positive diagnosis. Independent assessments from teachers would have been useful in examining the inter-rater reliability of the parent-raters however, this was beyond the scope of the current study and resources of the Education Department.

Despite these limitations, this study did attempt to assess the effects of ADHD on sustained attention independent of age, IQ and CD. The clinical evaluation, using commercially available rating scales and IQ measures demonstrates some of the difficulties in Psychology practice in diagnosing ADHD. In addition, the assessment of performance on CPT tasks is common practice in some Learning Disorder Assessment Centres and highlights the problems with the validity of these measures and the underlying constructs being evaluated. While it may be difficult to generalise the final results of this study due to its small sample size, it has highlighted several caveats for future consideration in ADHD research.

4.6. Future Directions for Further Research.

Future research into ADHD needs to focus on developing more reliable and valid diagnostic criteria. Employing more stringent criteria as suggested by Barkley (1990) would at least assist in identifying children's behaviours that were above the 93rd percentile clinical range, rather than simply counting the presence of symptoms. Further, using age specific norms would also help clinicians identify ADHD behaviours that are inappropriate to the child's chronological and mental age.

The high level co-morbid CD must be addressed when determining the specific deficit associated with ADHD. Further clarification regarding the relationship between these two diagnoses is also necessary. If children with

ADHD develop CD as a matter of course then the high level of Aggression and Delinquency could be viewed as a measure of severity rather than an additional diagnosis. Alternatively, if CD relates to specific ADHD symptoms such as hyperactivity, it may provide additional support for existing DSM-IV diagnostic sub-types of the disorder. Longitudinal studies evaluating the course of ADHD sub-types may further our understanding of how CD relates to the ADHD and its level of severity.

The definition of sustained attention also needs review. The employment of CPT as a definitive measure of sustained attention has been relatively unquestioned in past research. The failure to establish a clear relationship between CPT and behavioural measures of impulsivity, inattention and hyperactivity in this study also raises questions regarding the validity of the tasks employed. While the tasks in this study were longer than those used in previous research, it is unclear why the relationship between these variables becomes weaker as time on task increases. Future research assessing deficits in sustained attention in ADHD children needs to establish validity of CPT as a measure of sustained attention.

The failure to find differences between ADHD and controls on measures of CPT performance across time also raises doubts about inattention being one of the central features of the disorder. In this study ADHD subjects were able to maintain their attention as well as controls on both the Simple and Complex tasks. While some researchers

have argued that ADHD subjects have an application deficit, rather than an attention deficit this notion was not the focus of the present investigation.

Future studies need to assess how different contextual variables such as experimenters' presence, complexity of tasks etc. impede or enhance ADHD subjects' performance on CPTs. Such information would be useful in identifying factors that optimise performance on tasks requiring sustained attention that can be adopted in the classroom, home or social environments.

Further research could also explore how ADHD children perform on tasks as time is increased. Employing tasks that assess behaviour over a period of time would be expected to yield specific information on how children allocate and conserve their cognitive resources. Measuring time as a continuous variable rather than a consecutive discrete measure may help detect and understand more subtle variations in performance as time on tasks increases.

Finally, in order to be able to generalise the results of future studies larger subject groups are needed. The current study was limited to a small clinical sample of subjects who met the criteria for different sub-types of ADHD. More homogeneous clinical groups would provide more specific information about the deficits associated with ADD sub-types. That is, comparison of ADD and ADHD children may provide a clearer understanding of how different types of ADD subjects perform on measures of sustained attention if at all.

4.7. Conclusion.

The aims of the present study were three-fold. Firstly this study attempted to assess quantitative differences between ADHD and normal controls on tasks requiring attention. Secondly, in order to assess information processing models of ADHD deficits, both a Simple and Complex tasks were employed to compare rates of decrement between groups. Thirdly, this study aimed to assess the independence of ADHD diagnosis in predicting CPT performance as time on task increases.

Using Simple and Complex CPT tasks, ADHD and control subjects were tested over a period of time to assess their ability to sustain attention. While all subjects were found to perform worse on the Complex task, ADHD subjects did not show any significant differences in performance compared to the Control group. Further, there were no significant Group x Time x Task interactions on experimental measures. It was concluded that the ADHD subjects employed in this study did not demonstrate any deficits in sustained attention compared to normal Controls and that the decrement in performance was no greater than those found with the Control group on either of the tasks.

These findings were surprising given the past literature. Several reasons were identified as possibly contributing to the pattern of results obtained. Specifically, the ADHD subjects in this sample were approximately one year older than those employed in earlier

research and were significantly higher on CD scores than the controls. Questions regarding the validity of ADHD and its relationship with CD were raised as it was difficult to identify specific deficits associated with ADHD.

Further, the duration of the tasks employed in the present study was significantly longer than those employed previously. It is unclear how increased time on vigilance tasks affects the relationship with CPT and behavioural measures of Inattention, Impulsivity etc. The failure to provide concurrent validity on the experimental task with the behavioural measures also raises questions regarding the utility of the vigilance tasks as a measure of inattention.

Children's performance on tasks were found to increase as a function of Age and in some cases IQ. While the effects of ADHD diagnosis on task performance was insignificant, scores on Aggression and Delinquency factors did help predict CPT scores. It was concluded that ADHD added nothing to the model in terms of predicting CPT performance on any of the measures after adjusting for the effects of these other variables. The lack of independence of ADHD in predicting performance raises questions concerning the validity of this diagnosis, and/or the specific measurement tasks employed as meaningful indicators of the diagnosis.

Overall, the results of the current study failed to support the main hypotheses. It is likely that while ADHD children do not differ in their ability to sustain

attention on CPTs, they may have difficulties in applying themselves in situations that are less formal. Further research is needed to more fully understand the behavioural difficulties reported in ADHD children and the contextual factors that most influence their performance. Such research could usefully attempt to identify specific deficits associated with the core features of ADHD to further clarify the parameters of this disorder and the validity of the measures used to assess sustained attention.

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APPENDIX A: ADHD rating scale

BEHAVIOUR RATING SCALE

Child's Name _____ **Age** _____
School _____ **Grade** ____ **Teacher** _____

Please circle the number in the one column which best describes the child's behaviour over the last six months.

		Not at all	Just a little	Pretty much	Very much
1	Often fidgets or squirms in seat	0	1	2	3
2	Has difficulty remaining seated	0	1	2	3
3	Is easily distracted	0	1	2	3
4	Has difficulty awaiting turn in groups	0	1	2	3
5	Often blurts out answers to questions	0	1	2	3
6	Has difficulty following instructions	0	1	2	3
7	Has difficulty sustaining attention to tasks	0	1	2	3
8	Often shifts from one uncompleted activity to another	0	1	2	3
9	Has difficulty playing quietly	0	1	2	3
10	Often talks excessively	0	1	2	3
11	Often interrupts or intrudes on others	0	1	2	3
12	Often does not seem to listen	0	1	2	3
13	Often loses things necessary for tasks	0	1	2	3
14	Often engages in physically dangerous activities without considering consequences	0	1	2	3
15	Is often on the go or often acts as if driven by a motor	0	1	2	3
16	Often forgetful in daily activities	0	1	2	3
17	Often avoids or reluctant to engage in tasks that require sustained mental effort (ie schoolwork or homework)	0	1	2	3
18	Often experiences the above problems in other setting ie at both school and home	0	1	2	3

BEHAVIOUR RATING SCALE

Scoring procedure

1. To determine the number of symptoms present add the items rated as 2 or higher. DSM IV requires that 6 or more items are present in both inattentive and hyperactivity factors.

2. Add scores for each factor (excluding 15-17). If scores for total, factor 1 or factor 2 is above 1.5 standard deviations above the mean for the relevant age group, then behaviour is clinically significant.

3. Sub-groups determined by predominance of symptoms over the last 6 months
a) combined = high on both factors
b) ADD+H = high inattention and hyperactivity
c) ADD-H = high inattention and low hyperactivity

4. Question 18 should demonstrate pervasiveness of symptoms to meet DSM-IV criteria

Parent Rating	Teacher Rating
Factor 1 Inattention/hyperactivity sum items 1-3, 6-8,12-14 (16,17)	Factor 1 Inattention/hyperactivity sum items 1-3, 6-8, 12, 13 (16,17)
Factor 2 Impulsivity/Hyperactivity sum items 1,2,4,5,9-11,14 (15)	Factor 2 Impulsivity/Hyperactivity sum items 1,2,4,5,9-11,14,(15)

APPENDIX B: Information letter to parents of prospective control subjects.

Dear Parents/Guardians,

Research on Attention

I am employed as a Psychologist in Cowra and as part of my Clinical Masters Degree in Psychology at the Australian National University in Canberra I am conducting a study to assess children's capacity to concentrate. More specifically, I am interested in how long children are able to attend to specific tasks and whether attention is influenced by children's overall behaviour and general ability.

I would like to request permission for your son to participate in this study. I plan to test between 60 and 80 boys between the age of 7 and 12 years (inclusively). Each child has been randomly selected from class rolls. All assessments will be conducted at school. Testing will take approximately one hour for each child and this will include completion of two 20 minute game like computer tasks and a general assessment task. In addition, I am requesting parents to fill out two questionnaires.

Your child's participation is voluntary and he may withdraw from the study at any time. All information obtained in the study is completely confidential. Personal details and individual results will not be included in the data. Only group data will be reported.

Please keep this information sheet. Attached is a consent form to fill out if you give your permission for your son to participate. I will forward the questionnaires to you in the next week or so. If you have any concerns or questions regarding your child's participation in this study please contact me through the school or on 41 2196 Wednesday to Friday. Thankyou for your assistance.

Yours sincerely,

Anna Britton,
Psychologist

APPENDIX C: Consent form for control group

CONSENT FORM

I _____ (please print name) give my permission for my child _____ to participate in the study on attention which is being conducted by Anna Britton.

I agree to complete two questionnaires for the study which will be sent to my home address.

I understand that participation in the study is voluntary and that my child or I may withdraw at any time.

I understand that all results will be completely confidential and that personal details and individual results will not be included in the data and that only group data will be reported.

_____ (parent/guardian's signature)

APPENDIX D: Letter for controls re questionnaires.

RESEARCH ON ATTENTION

Dear Parents/Guardians,

I would like to take this opportunity to thank you for you participation in the research on attention being conducted at Mulyan Primary School.

Following up from my last letter, I have enclosed two behavioural questionnaires and would appreciate your time in completing them. If possible I would like you to answer all the questions asked. If there are any specific questions that you do not want to answer please indicate with a tick so that I know you have passed on that item. All information obtained in this study is completely confidential.

At this stage I would like to commence testing during the next school term. I would appreciate it if you could return your completed questionnaires in the original envelope to me via the school office. Any questionnaires not completed should also be returned if possible.

If you have any questions regarding these forms please feel free to contact me on XX XXXX.

Thank you for your assistance.

Yours sincerely,

Anna Britton,
Psychologist.

APPENDIX E: Information letter to parents of clinical subjects

Dear Parents/Guardians,

Research on Attention

I am employed as a Psychologist in Cowra and as part of my Clinical Masters Degree in Psychology at the Australian National University in Canberra I am conducting a study to assess children's capacity to concentrate. More specifically, I am interested in how long children are able to attend to specific tasks and whether attention is influenced by children's overall behaviour and their general abilities.

I would like to request permission for your son to participate in this study as part of a general psychological assessment. Testing will take approximately one hour for each child and this will include completion of two 20 minute game like computer tasks and a general assessment task. In addition, I am requesting parents to fill out two questionnaires. This information will be reported back to Dr Mulcahy to assist with ongoing treatment options.

Your child's participation is voluntary and he may withdraw from the study at any time. Your decision not to participate will not prejudice your son's treatment in any way. All information obtained in the study is completely confidential. Personal details and individual results will not be included in the data. Only group data will be reported in the study.

Please keep this information sheet. Attached is a consent form to fill out if you give your permission for your son to participate. I have enclosed two behaviour questionnaires for you to complete. If you have any concerns or questions regarding your child's participation in this study or would like to make an appointment please contact me on 41 2196. Thankyou for your assistance.

Yours sincerely,

Anna Britton,
Psychologist

APPENDIX F: Consent form for clinical group

CONSENT FORM

I _____ (please print name) give my permission for my child _____ to participate in the study on attention which is being conducted by Anna Britton.

I give my permission to Anna Britton to provide a brief report to Consultant Paediatrician, Dr D. Mulcahy summarising the information on the behavioural questionnaires that I have completed.

I understand that participation in the study is voluntary and that my child or I may withdraw at any time.

I understand that all results will be completely confidential and that personal details and individual results will not be included in the data and that only group data will be reported in the study.

_____

(parent/guardian's signature)

APPENDIX G: Raw scores for CPT and behavioural measures

Forty eight subjects were scored on CPT and behavioural measures. The variable codes on the following pages are listed in the first row and include:

ID	Subject identification code
GROUP	Group membership (1 is ADHD and 2 is Controls)
INATTEN	z scores for ADHD rating of Inattention
IMPUL	Z scores for ADHD rating of Impulsivity
ORD12	Order of CPT task presentation (1 is simple then complex; 2 is complex then simple)
MONTHS	Subject age in months
IQ	Pro-rata IQ scores
HY	CBCL Hyperactivity rating
AG	CBCL Aggression rating
DEL	CBCL Delinquency rating
NTARG	Mean number of targets in each epoch x 32
CORR	Percent of correct hits for each epoch x 32
MRT	Mean reaction time for each epoch x 32
COMM	Percent of commission errors for each epoch x 32

Note: There are 32 x CPT scores. The first 16 scores (epoch 1 to 16) represent scores obtained on the simple CPT. Epoch 17 to 32 represent scores for the complex tasks.

	I	GROUP	NATTEN	IMPUL	ORD12	MONTHS	IQ	HY	AG	DE	NTAR01	CORR01	MRT01	COMM01	TAR02	CORR02	MRT02	COMM02	NTAR03	CORR03	MRT03	COMM03	TAR04
1	ad	1.0	2.14	2.50	2.00	99.00	81.0	82.0	87.0	84.0	6.0	100.0	845.0	.0	7.0	85.0	1045.0	.0	4.0	50.0	1120.0	2.0	5.0
2	ae	1.0	.87	-.10	1.00	109.80	130.0	63.0	75.0	67.0	5.0	100.0	466.0	2.0	8.0	87.0	518.6	.0	8.0	100.0	571.3	2.0	7.0
3	aj	2.0	-.75	-.99	2.00	105.00	109.0	55.0	55.0	55.0	7.0	100.0	802.9	.0	5.0	100.0	850.0	.0	7.0	100.0	724.3	.0	8.0
4	al	2.0	-.45	-.60	2.00	115.20	100.0	55.0	55.0	55.0	4.0	100.0	595.0	.0	5.0	100.0	706.0	.0	3.0	100.0	710.0	.0	7.0
5	an	1.0	2.50	1.87	1.00	115.20	94.0	84.0	85.0	83.0	4.0	100.0	540.0	2.0	5.0	100.0	696.0	.0	6.0	100.0	635.0	.0	6.0
6	an	2.0	1.09	1.84	1.00	100.80	88.0	86.0	70.0	67.0	6.0	83.0	806.0	2.0	7.0	100.0	888.6	.0	8.0	100.0	802.5	.0	8.0
7	an	2.0	-.15	-.05	1.00	142.80	92.0	62.0	71.0	65.0	4.0	75.0	633.3	.0	6.0	100.0	580.0	2.0	5.0	100.0	608.0	.0	6.0
8	aw	1.0	1.62	1.50	1.00	105.00	101.0	69.0	69.0	75.0	4.0	100.0	762.5	.0	7.0	100.0	871.4	.0	4.0	100.0	900.0	.0	4.0
9	bc	2.0	.87	.91	1.00	90.00	111.0	67.0	85.0	79.0	8.0	87.0	628.6	.0	8.0	87.0	611.4	.0	5.0	80.0	582.5	.0	7.0
10	bp	2.0	-1.14	-1.16	1.00	99.00	113.0	55.0	55.0	55.0	7.0	100.0	644.3	2.0	6.0	100.0	615.0	2.0	7.0	100.0	690.0	.0	8.0
11	bs	2.0	-.87	-1.09	2.00	117.00	112.0	55.0	55.0	55.0	5.0	100.0	696.0	.0	5.0	100.0	696.0	2.0	8.0	100.0	657.5	.0	4.0
12	bw	1.0	1.72	2.92	1.00	129.96	109.0	82.0	73.0	68.0	7.0	100.0	722.9	2.0	7.0	71.0	784.0	2.0	6.0	100.0	863.3	2.0	6.0
13	bw	2.0	-.35	-.66	1.00	97.80	115.0	57.0	67.0	55.0	2.0	100.0	680.0	.0	4.0	100.0	720.0	.0	6.0	100.0	808.3	2.0	3.0
14	bw	2.0	-.52	-.93	1.00	138.00	88.0	55.0	55.0	55.0	8.0	100.0	542.5	.0	8.0	100.0	543.8	2.0	6.0	100.0	588.3	.0	6.0
15	cp	1.0	1.24	-.60	1.00	141.96	82.0	73.0	58.0	61.0	7.0	100.0	621.4	.0	6.0	100.0	690.0	.0	6.0	100.0	643.3	4.0	6.0
16	cp	2.0	.13	.45	2.00	93.00	101.0	55.0	55.0	55.0	8.0	.0	1500.0	.0	6.0	.0	1500.0	13.0	4.0	.0	1500.0	21.0	6.0
17	dc	1.0	1.42	1.37	1.00	115.20	86.0	80.0	92.0	89.0	6.0	100.0	588.3	.0	5.0	100.0	740.0	.0	6.0	100.0	653.3	.0	4.0
18	dr	1.0	1.24	1.04	2.00	109.80	113.0	65.0	82.0	73.0	5.0	100.0	982.0	.0	5.0	20.0	1530.0	.0	6.0	83.0	1146.0	2.0	9.0
19	ds	2.0	.82	.39	2.00	118.20	115.0	55.0	55.0	57.0	7.0	100.0	724.3	.0	6.0	100.0	773.3	.0	6.0	83.0	674.0	.0	4.0
20	hb	2.0	-.49	-.99	1.00	99.60	62.0	62.0	55.0	57.0	6.0	100.0	735.0	2.0	7.0	100.0	667.1	2.0	5.0	100.0	772.0	2.0	6.0
21	im	2.0	-.65	-.66	1.00	139.20	123.0	55.0	55.0	55.0	5.0	100.0	508.0	.0	5.0	100.0	498.0	.0	9.0	100.0	550.0	2.0	6.0
22	jb	2.0	-.59	-.93	1.00	115.20	98.0	55.0	55.0	55.0	5.0	100.0	674.0	.0	6.0	100.0	763.3	.0	7.0	100.0	778.6	.0	8.0
23	jk	2.0	-1.01	-.99	2.00	99.00	107.0	55.0	55.0	55.0	7.0	100.0	754.3	2.0	5.0	100.0	696.0	.0	3.0	100.0	670.0	.0	4.0
24	jm	2.0	-.73	-.60	2.00	114.00	107.0	55.0	55.0	61.0	6.0	100.0	770.0	.0	6.0	100.0	873.3	.0	5.0	100.0	640.0	13.0	4.0
25	kb	1.0	1.72	.14	2.00	121.80	100.0	78.0	55.0	61.0	8.0	100.0	701.3	.0	7.0	85.0	753.3	.0	6.0	100.0	1000.0	4.0	5.0
26	ks	1.0	2.14	2.34	1.00	102.96	111.0	86.0	85.0	79.0	6.0	100.0	690.0	2.0	5.0	100.0	620.0	2.0	9.0	44.0	887.5	2.0	7.0
27	lc	1.0	1.09	-.16	2.00	106.80	118.0	85.0	61.0	76.0	3.0	100.0	580.0	34.0	4.0	100.0	735.0	.0	7.0	71.0	830.0	.0	5.0
28	lh	1.0	1.74	1.93	2.00	87.00	118.0	66.0	77.0	67.0	5.0	100.0	784.0	2.0	1.0	100.0	820.0	.0	4.0	100.0	720.0	.0	6.0
29	ls	2.0	-.22	-.01	1.00	99.96	103.0	57.0	63.0	68.0	7.0	85.0	810.0	4.0	7.0	85.0	890.0	2.0	7.0	100.0	912.9	.0	4.0
30	md	2.0	-1.24	-.90	2.00	127.20	115.0	55.0	55.0	55.0	7.0	100.0	675.7	.0	4.0	100.0	735.0	.0	5.0	80.0	665.0	.0	3.0
31	mh	2.0	-.25	-.15	1.00	103.20	115.0	57.0	63.0	68.0	5.0	100.0	520.0	4.0	5.0	100.0	654.0	4.0	3.0	100.0	633.3	.0	4.0
32	mh	2.0	-1.02	-.81	1.00	141.00	118.0	55.0	55.0	55.0	5.0	100.0	532.0	.0	8.0	100.0	528.8	2.0	6.0	100.0	578.3	.0	6.0
33	mh	2.0	-.22	-.33	2.00	105.60	107.0	55.0	72.0	67.0	9.0	66.0	808.3	.0	4.0	100.0	790.0	.0	4.0	25.0	930.0	.0	4.0
34	ms	2.0	-.27	-.51	2.00	135.60	107.0	55.0	55.0	55.0	6.0	100.0	651.7	.0	5.0	100.0	794.0	.0	5.0	100.0	752.0	.0	7.0
35	mw	1.0	1.80	1.70	2.00	108.96	111.0	60.0	70.0	68.0	4.0	100.0	860.0	.0	4.0	100.0	845.0	2.0	4.0	50.0	790.0	.0	6.0
36	mw	1.0	.34	.71	2.00	141.96	105.0	71.0	88.0	75.0	4.0	100.0	747.5	.0	5.0	100.0	808.0	4.0	7.0	100.0	787.1	.0	6.0
37	nm	1.0	1.83	1.47	2.00	138.00	107.0	73.0	93.0	83.0	8.0	100.0	631.3	.0	6.0	100.0	551.7	.0	5.0	100.0	574.0	.0	5.0
38	nt	2.0	.17	.17	2.00	99.60	115.0	62.0	76.0	62.0	8.0	100.0	756.3	2.0	8.0	100.0	837.5	2.0	7.0	100.0	707.1	.0	5.0
39	pw	2.0	-.60	-.90	1.00	126.00	113.0	55.0	55.0	55.0	6.0	100.0	606.7	.0	4.0	100.0	655.0	.0	5.0	100.0	706.0	.0	4.0
40	rs	2.0	-1.24	-1.26	1.00	130.20	97.0	55.0	55.0	55.0	7.0	100.0	558.6	2.0	5.0	100.0	542.0	.0	5.0	100.0	740.0	.0	7.0
41	sg	1.0	-.45	-.76	1.00	109.80	91.0	62.0	55.0	56.0	6.0	83.0	664.0	.0	4.0	100.0	667.5	.0	5.0	60.0	890.0	.0	6.0
42	sh	2.0	1.46	1.96	2.00	129.60	81.0	64.0	85.0	78.0	8.0	100.0	638.8	.0	9.0	100.0	658.9	.0	8.0	87.0	675.7	.0	9.0
43	sl	2.0	.87	-.10	2.00	87.00	86.0	55.0	59.0	60.0	4.0	100.0	1050.0	.0	4.0	75.0	926.7	2.0	8.0	100.0	1030.0	.0	8.0
44	sm	1.0	1.88	1.93	2.00	102.00	100.0	85.0	70.0	73.0	7.0	100.0	1030.0	.0	7.0	100.0	1061.4	.0	2.0	100.0	1200.0	.0	6.0
45	tl	2.0	-.35	-1.16	1.00	105.00	100.0	55.0	55.0	55.0	3.0	100.0	706.7	.0	4.0	100.0	747.5	.0	4.0	100.0	802.5	.0	9.0
46	tp	2.0	.47	1.47	2.00	133.80	103.0	66.0	76.0	68.0	9.0	100.0	610.0	.0	3.0	100.0	780.0	2.0	2.0	100.0	680.0	2.0	6.0
47	ts	2.0	-.35	-.01	2.00	103.20	119.0	55.0	55.0	55.0	6.0	100.0	790.0	.0	9.0	88.0	810.0	.0	5.0	80.0	762.5	2.0	5.0
48	wt	1.0	2.08	1.70	1.00	108.00	113.0	90.0	69.0	65.0	6.0	100.0	625.0	2.0	7.0	100.0	614.3	.0	6.0	100.0	643.3	.0	8.0

CORR04	MRT04	OMM04	TAR05	CORR05	MRT05	COMM05	TAR06	CORR06	MRT06	OMM06	NTAR07	CORR07	MRT07	COMM07	NTAR08	CORR08	MRT08	COMM08	NTAR09	CORR09	MRT09	COMM09	NTAR10
100.0	1036.0	4.0	5.0	60.0	780.0	8.0	7.0	57.0	847.5	6.0	7.0	85.0	900.0	6.0	6.0	100.0	745.0	18.0	8.0	100.0	795.0	4.0	6.0
100.0	685.7	.0	6.0	83.0	608.0	.0	6.0	100.0	635.0	.0	4.0	75.0	540.0	.0	8.0	100.0	638.8	.0	8.0	100.0	776.2	.0	9.0
75.0	890.0	.0	7.0	85.0	873.3	.0	4.0	100.0	940.0	2.0	3.0	66.0	820.0	.0	5.0	80.0	967.5	.0	9.0	88.0	790.0	2.0	6.0
100.0	691.4	.0	4.0	75.0	743.3	.0	8.0	75.0	655.0	.0	7.0	85.0	615.0	2.0	7.0	100.0	692.9	.0	5.0	100.0	686.0	.0	8.0
100.0	641.7	.0	4.0	75.0	653.3	.0	2.0	100.0	735.0	.0	5.0	100.0	772.0	.0	5.0	100.0	686.0	.0	5.0	80.0	805.0	.0	5.0
100.0	796.3	.0	4.0	100.0	900.0	2.0	5.0	80.0	845.0	2.0	8.0	87.0	808.6	2.0	6.0	83.0	884.0	.0	5.0	60.0	816.7	2.0	3.0
100.0	660.0	.0	7.0	100.0	660.0	.0	8.0	87.0	644.3	.0	4.0	100.0	667.5	.0	5.0	100.0	752.0	.0	7.0	100.0	628.6	.0	3.0
100.0	860.0	.0	8.0	100.0	872.5	.0	7.0	100.0	911.4	.0	7.0	100.0	905.7	.0	4.0	100.0	845.0	.0	9.0	100.0	940.0	.0	6.0
100.0	715.7	.0	2.0	100.0	625.0	2.0	7.0	28.0	760.0	.0	8.0	75.0	660.0	.0	5.0	100.0	708.0	.0	7.0	85.0	708.3	.0	6.0
62.0	642.0	2.0	6.0	66.0	652.5	.0	7.0	71.0	642.0	.0	4.0	100.0	682.5	.0	6.0	66.0	652.5	2.0	7.0	71.0	642.0	.0	7.0
75.0	710.0	.0	5.0	80.0	637.5	.0	3.0	66.0	845.0	.0	8.0	100.0	755.0	.0	6.0	83.0	808.0	.0	4.0	100.0	680.0	.0	3.0
100.0	745.0	6.0	4.0	75.0	910.0	2.0	4.0	100.0	900.0	4.0	4.0	100.0	1010.0	4.0	6.0	83.0	1014.0	4.0	6.0	83.0	774.0	2.0	6.0
100.0	780.0	.0	5.0	100.0	862.0	.0	7.0	100.0	784.3	.0	7.0	100.0	700.0	.0	7.0	100.0	780.0	.0	8.0	100.0	866.3	.0	9.0
83.0	652.0	.0	6.0	100.0	578.3	.0	4.0	100.0	585.0	.0	6.0	100.0	716.7	.0	6.0	83.0	676.0	.0	9.0	100.0	608.9	.0	.0
100.0	726.7	6.0	5.0	100.0	674.0	.0	6.0	100.0	708.3	.0	4.0	100.0	695.0	2.0	2.0	100.0	815.0	.0	4.0	75.0	763.3	.0	5.0
16.0	490.0	.0	2.0	.0	1500.0	4.0	5.0	80.0	830.0	2.0	7.0	57.0	967.5	6.0	6.0	66.0	735.0	.0	7.0	42.0	946.7	2.0	5.0
100.0	695.0	.0	5.0	100.0	696.0	.0	6.0	100.0	671.7	2.0	4.0	100.0	612.5	.0	5.0	100.0	674.0	.0	3.0	66.0	790.0	.0	6.0
77.0	1061.4	2.0	7.0	71.0	982.0	.0	7.0	85.0	1071.7	.0	5.0	80.0	1107.5	.0	6.0	83.0	1092.0	2.0	8.0	75.0	981.7	.0	3.0
75.0	706.7	.0	8.0	100.0	773.8	.0	5.0	100.0	806.0	.0	2.0	100.0	845.0	.0	3.0	66.0	735.0	.0	7.0	100.0	820.0	.0	7.0
83.0	804.0	4.0	7.0	71.0	764.0	6.0	4.0	100.0	775.0	2.0	7.0	100.0	918.6	2.0	6.0	83.0	852.0	4.0	5.0	100.0	796.0	2.0	5.0
100.0	590.0	.0	4.0	100.0	610.0	.0	9.0	100.0	591.1	.0	5.0	100.0	620.0	.0	3.0	100.0	560.0	.0	7.0	100.0	574.3	.0	8.0
100.0	858.8	.0	8.0	87.0	754.3	.0	7.0	100.0	808.6	.0	8.0	87.0	770.0	.0	5.0	100.0	894.0	.0	6.0	66.0	875.0	.0	4.0
75.0	596.7	.0	7.0	100.0	804.3	4.0	5.0	100.0	696.0	2.0	4.0	75.0	670.0	2.0	4.0	100.0	805.0	.0	6.0	100.0	945.0	2.0	7.0
100.0	815.0	.0	9.0	66.0	916.7	2.0	4.0	100.0	1037.5	.0	8.0	87.0	771.4	2.0	4.0	75.0	780.0	.0	4.0	100.0	1007.5	.0	.0
100.0	950.0	.0	8.0	100.0	907.5	4.0	3.0	100.0	963.3	.0	6.0	100.0	816.7	.0	8.0	62.0	918.0	.0	4.0	100.0	902.5	2.0	5.0
85.0	816.7	2.0	6.0	83.0	906.0	.0	5.0	80.0	1147.5	2.0	5.0	100.0	940.0	4.0	4.0	100.0	845.0	.0	3.0	100.0	816.7	2.0	8.0
80.0	777.5	.0	7.0	85.0	918.3	.0	6.0	83.0	862.0	.0	7.0	85.0	873.3	.0	5.0	60.0	743.3	.0	4.0	75.0	836.7	2.0	7.0
100.0	900.0	.0	7.0	100.0	921.4	.0	3.0	100.0	873.3	2.0	4.0	75.0	1000.0	2.0	7.0	57.0	900.0	2.0	6.0	100.0	946.7	.0	7.0
100.0	927.5	.0	4.0	75.0	890.0	.0	8.0	87.0	794.3	.0	4.0	100.0	830.0	.0	8.0	100.0	836.3	.0	7.0	57.0	1040.0	2.0	6.0
100.0	893.3	.0	7.0	85.0	735.0	.0	7.0	100.0	827.1	.0	5.0	100.0	860.0	.0	6.0	100.0	645.0	.0	7.0	100.0	724.3	.0	4.0
100.0	622.5	.0	5.0	100.0	642.0	.0	7.0	100.0	628.6	.0	7.0	100.0	590.0	.0	3.0	100.0	670.0	.0	5.0	100.0	642.0	.0	5.0
100.0	568.3	.0	7.0	100.0	581.4	.0	5.0	100.0	596.0	.0	7.0	100.0	620.0	.0	4.0	100.0	597.5	.0	7.0	100.0	582.9	.0	5.0
50.0	680.0	2.0	7.0	85.0	881.7	.0	7.0	100.0	897.1	.0	7.0	71.0	840.0	.0	5.0	100.0	894.0	.0	4.0	75.0	1073.3	2.0	5.0
100.0	825.7	.0	5.0	100.0	698.0	.0	5.0	100.0	872.0	.0	4.0	75.0	780.0	2.0	7.0	100.0	768.6	.0	6.0	100.0	696.7	.0	4.0
100.0	845.0	.0	8.0	100.0	782.5	7.0	5.0	100.0	772.0	.0	8.0	100.0	823.8	2.0	.0	70.0	754.3	2.0	3.0	100.0	800.0	.0	8.0
100.0	716.7	.0	5.0	100.0	972.0	.0	8.0	100.0	770.0	2.0	6.0	100.0	770.0	2.0	3.0	100.0	870.0	.0	6.0	100.0	853.3	.0	.0
100.0	662.0	.0	5.0	100.0	564.0	.0	9.0	100.0	732.2	.0	7.0	100.0	692.9	2.0	7.0	100.0	787.1	.0	7.0	100.0	627.1	2.0	8.0
80.0	732.5	.0	6.0	100.0	883.3	.0	6.0	100.0	635.0	.0	8.0	100.0	721.2	.0	7.0	100.0	691.4	.0	7.0	85.0	790.0	.0	4.0
100.0	777.5	.0	5.0	100.0	642.0	.0	6.0	100.0	633.3	.0	6.0	100.0	708.3	2.0	1.0	100.0	540.0	.0	8.0	100.0	718.8	.0	6.0
100.0	605.7	.0	7.0	100.0	652.9	.0	6.0	100.0	680.0	.0	6.0	100.0	706.7	.0	7.0	100.0	642.9	.0	2.0	100.0	820.0	.0	5.0
100.0	890.0	.0	7.0	100.0	794.3	.0	.0	100.0	899.0	.0	5.0	100.0	818.0	.0	5.0	100.0	850.0	.0	6.0	66.0	967.5	.0	5.0
100.0	732.2	.0	5.0	100.0	684.0	.0	7.0	100.0	724.3	2.0	6.0	100.0	706.7	2.0	6.0	100.0	690.0	2.0	6.0	100.0	798.3	.0	5.0
100.0	988.8	.0	9.0	77.0	1061.4	2.0	4.0	75.0	1053.3	2.0	3.0	100.0	1146.7	.0	9.0	66.0	1166.7	.0	6.0	83.0	1246.0	.0	4.0
100.0	1110.0	.0	6.0	50.0	1240.0	.0	5.0	100.0	1192.0	.0	5.0	80.0	1230.0	.0	2.0	50.0	1040.0	.0	7.0	85.0	1108.3	.0	9.0
100.0	805.6	.0	8.0	100.0	837.5	.0	3.0	100.0	800.0	.0	5.0	100.0	862.0	.0	5.0	100.0	706.0	.0	5.0	100.0	818.0	.0	7.0
100.0	725.0	.0	6.0	100.0	871.7	2.0	8.0	100.0	687.5	.0	5.0	100.0	816.0	2.0	3.0	100.0	673.3	.0	6.0	66.0	765.0	.0	5.0
100.0	992.0	.0	5.0	100.0	928.0	.0	9.0	88.0	783.7	2.0	5.0	100.0	984.0	.0	2.0	100.0	1010.0	2.0	5.0	100.0	796.0	.0	7.0
100.0	646.3	.0	6.0	100.0	743.3	.0	7.0	100.0	724.3	.0	6.0	100.0	670.0	.0	8.0	100.0	651.2	.0	6.0	100.0	633.3	.0	7.0

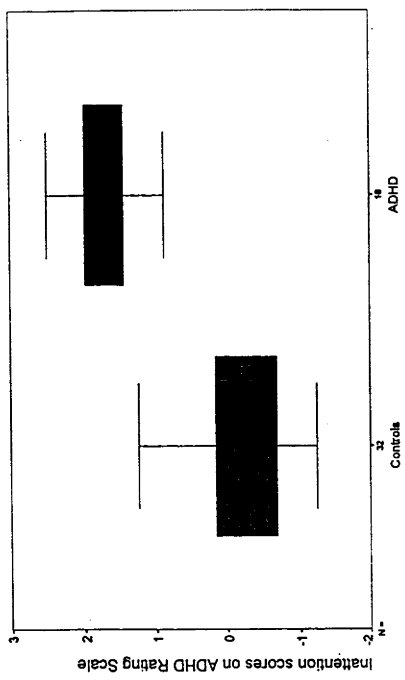
CORR10	MRT10	OMM10	TAR11	CORR11	MRT11	COMM11	TAR12	CORR12	MRT12	COMM12	TAR13	CORR13	MRT13	COMM13	NTAR14	CORR14	MRT14	COMM14	NTAR15	CORR15	MRT15	OMM15
83.0	1048.0	2.0	5.0	80.0	1037.5	.0	8.0	100.0	915.0	.0	5.0	100.0	798.0	2.0	5.0	80.0	927.5	.0	7.0	85.0	928.3	.0
100.0	592.2	2.0	6.0	100.0	568.3	.0	4.0	100.0	570.0	4.0	6.0	100.0	763.3	.0	5.0	100.0	684.0	.0	3.0	100.0	780.0	.0
83.0	872.0	2.0	8.0	87.0	848.6	.0	3.0	66.0	845.0	.0	5.0	80.0	942.5	2.0	7.0	71.0	950.0	2.0	3.0	66.0	845.0	.0
100.0	652.5	.0	5.0	100.0	696.0	.0	6.0	100.0	715.0	.0	6.0	100.0	698.3	.0	5.0	100.0	838.0	.0	8.0	87.0	668.6	.0
100.0	828.0	.0	6.0	100.0	753.3	.0	5.0	100.0	684.0	.0	3.0	100.0	743.3	.0	8.0	100.0	782.5	.0	7.0	85.0	688.3	.0
100.0	1056.7	.0	5.0	80.0	967.5	.0	8.0	62.0	894.0	2.0	5.0	60.0	853.3	.0	9.0	88.0	823.8	.0	8.0	87.0	794.3	2.0
100.0	613.3	.0	4.0	100.0	637.5	.0	9.0	100.0	724.4	.0	5.0	100.0	654.0	2.0	5.0	80.0	667.5	.0	2.0	100.0	680.0	.0
83.0	938.0	.0	8.0	100.0	892.5	.0	7.0	100.0	850.0	.0	5.0	100.0	838.0	.0	4.0	100.0	1035.0	.0	8.0	75.0	900.0	.0
66.0	720.0	2.0	6.0	83.0	728.0	.0	3.0	66.0	705.0	.0	3.0	33.0	600.0	.0	7.0	.0	1500.0	.0	7.0	.0	1500.0	.0
100.0	692.9	.0	3.0	100.0	653.3	.0	4.0	50.0	900.0	.0	6.0	100.0	781.7	.0	8.0	75.0	780.0	.0	8.0	100.0	735.0	.0
66.0	870.0	.0	5.0	100.0	742.0	.0	3.0	66.0	735.0	.0	6.0	100.0	900.0	2.0	8.0	75.0	696.7	4.0	7.0	85.0	778.3	2.0
66.0	982.5	.0	5.0	80.0	1135.0	.0	6.0	100.0	898.3	4.0	7.0	85.0	918.3	2.0	4.0	50.0	1175.0	.0	7.0	85.0	975.0	9.0
100.0	847.8	.0	5.0	100.0	862.0	.0	5.0	100.0	906.0	.0	8.0	100.0	927.5	.0	5.0	100.0	840.0	.0	8.0	87.0	872.9	2.0
100.0	685.0	.0	3.0	100.0	746.7	.0	5.0	100.0	716.0	.0	5.0	100.0	772.0	.0	6.0	100.0	670.0	.0	3.0	100.0	710.0	.0
100.0	696.0	.0	6.0	100.0	736.7	.0	6.0	100.0	743.3	.0	5.0	80.0	775.0	.0	4.0	75.0	816.7	.0	5.0	100.0	762.0	.0
40.0	845.0	.0	6.0	100.0	733.3	.0	7.0	100.0	778.6	.0	7.0	57.0	787.5	.0	6.0	83.0	950.0	2.0	7.0	42.0	853.3	2.0
83.0	740.0	.0	6.0	100.0	818.3	.0	4.0	100.0	612.5	.0	6.0	100.0	716.7	.0	6.0	66.0	682.5	.0	5.0	100.0	728.0	2.0
66.0	1310.0	4.0	5.0	60.0	1020.0	.0	4.0	50.0	1205.0	2.0	8.0	37.0	946.7	.0	2.0	100.0	900.0	.0	5.0	20.0	1040.0	.0
100.0	724.3	.0	4.0	100.0	900.0	.0	5.0	100.0	828.0	.0	5.0	100.0	830.0	.0	4.0	100.0	887.5	.0	5.0	100.0	862.0	.0
100.0	906.0	.0	6.0	50.0	1240.0	2.0	7.0	42.0	910.0	4.0	5.0	100.0	806.0	4.0	7.0	71.0	840.0	6.0	4.0	100.0	887.5	32.0
100.0	548.8	.0	9.0	100.0	573.3	.0	6.0	100.0	596.7	.0	7.0	100.0	612.9	.0	5.0	100.0	554.0	.0	5.0	100.0	620.0	.0
75.0	870.0	.0	3.0	100.0	763.3	.0	8.0	87.0	822.9	.0	6.0	83.0	840.0	.0	6.0	100.0	670.0	.0	4.0	100.0	775.0	.0
85.0	755.0	.0	3.0	66.0	790.0	.0	4.0	50.0	820.0	.0	7.0	85.0	781.7	.0	6.0	83.0	698.0	.0	3.0	100.0	690.0	.0
90.0	866.7	.0	7.0	85.0	910.0	6.0	6.0	83.0	860.0	.0	5.0	100.0	828.0	.0	7.0	100.0	864.3	.0	7.0	100.0	912.9	.0
100.0	870.0	.0	6.0	83.0	830.0	.0	5.0	100.0	992.0	6.0	7.0	85.0	926.7	6.0	7.0	71.0	982.0	.0	7.0	85.0	798.3	.0
87.0	707.1	.0	7.0	100.0	701.4	9.0	5.0	80.0	765.0	4.0	4.0	100.0	885.0	8.0	1.0	100.0	710.0	.0	7.0	57.0	1037.5	6.0
71.0	842.0	.0	8.0	87.0	935.7	.0	9.0	88.0	770.0	2.0	5.0	60.0	963.3	.0	5.0	80.0	790.0	.0	9.0	77.0	927.1	.0
85.0	908.3	2.0	4.0	75.0	726.7	.0	5.0	100.0	720.0	.0	1.0	100.0	760.0	.0	5.0	100.0	1070.0	.0	4.0	75.0	906.7	.0
66.0	805.0	4.0	6.0	66.0	860.0	2.0	7.0	71.0	894.0	2.0	6.0	83.0	886.0	.0	4.0	100.0	872.5	2.0	3.0	100.0	1053.3	.0
100.0	845.0	.0	3.0	100.0	780.0	.0	4.0	100.0	845.0	4.0	7.0	100.0	762.9	.0	3.0	100.0	906.7	.0	8.0	100.0	728.8	.0
100.0	554.0	.0	8.0	100.0	597.5	2.0	5.0	100.0	640.0	.0	5.0	100.0	750.0	.0	5.0	100.0	676.0	.0	4.0	100.0	677.5	.0
100.0	606.0	.0	6.0	100.0	580.0	.0	5.0	100.0	618.0	.0	6.0	100.0	605.0	.0	5.0	100.0	620.0	.0	5.0	100.0	620.0	.0
80.0	845.0	.0	6.0	100.0	781.7	.0	6.0	83.0	872.0	.0	5.0	60.0	800.0	.0	5.0	40.0	925.0	.0	4.0	75.0	1053.3	.0
100.0	777.5	.0	5.0	100.0	818.0	.0	6.0	100.0	800.0	.0	4.0	100.0	732.5	.0	5.0	100.0	706.0	.0	2.0	100.0	765.0	.0
62.0	796.0	.0	4.0	75.0	780.0	.0	4.0	75.0	726.7	2.0	4.0	100.0	845.0	2.0	4.0	75.0	796.7	2.0	1.0	100.0	1370.0	.0
100.0	829.0	.0	6.0	100.0	826.7	.0	2.0	100.0	1230.0	.0	6.0	100.0	863.3	.0	3.0	100.0	816.7	2.0	2.0	100.0	820.0	.0
100.0	681.3	2.0	4.0	100.0	625.0	.0	6.0	83.0	696.0	.0	4.0	100.0	792.5	.0	8.0	100.0	682.5	2.0	6.0	100.0	625.0	.0
100.0	682.5	.0	3.0	100.0	706.7	.0	4.0	100.0	900.0	.0	6.0	100.0	691.7	.0	6.0	100.0	708.3	.0	5.0	100.0	718.0	.0
100.0	763.3	2.0	8.0	100.0	768.8	.0	3.0	100.0	746.7	.0	6.0	100.0	801.7	.0	8.0	100.0	770.0	.0	5.0	100.0	840.0	.0
100.0	720.0	.0	7.0	100.0	691.4	.0	7.0	100.0	614.3	.0	3.0	100.0	853.3	.0	4.0	100.0	790.0	.0	6.0	83.0	622.0	2.0
100.0	874.0	.0	5.0	80.0	872.5	.0	4.0	100.0	900.0	.0	6.0	83.0	1026.0	.0	3.0	100.0	983.3	.0	6.0	83.0	960.0	.0
100.0	708.0	.0	8.0	100.0	790.0	4.0	2.0	100.0	790.0	2.0	6.0	100.0	853.3	.0	5.0	100.0	762.0	.0	5.0	100.0	940.0	.0
50.0	1175.0	.0	8.0	50.0	1050.0	2.0	5.0	40.0	1260.0	.0	5.0	40.0	1145.0	.0	4.0	50.0	1035.0	2.0	6.0	66.0	1010.0	2.0
88.0	1072.5	.0	5.0	60.0	1313.3	.0	7.0	100.0	1122.9	.0	7.0	85.0	973.3	.0	9.0	55.0	1014.0	.0	3.0	66.0	980.0	.0
100.0	762.9	.0	5.0	100.0	828.0	.0	7.0	100.0	792.9	.0	8.0	100.0	823.8	.0	6.0	100.0	808.3	.0	8.0	100.0	823.8	.0
80.0	997.5	.0	4.0	100.0	692.5	.0	4.0	100.0	750.0	.0	6.0	100.0	671.7	.0	7.0	100.0	675.7	2.0	7.0	100.0	745.7	2.0
85.0	993.3	.0	6.0	100.0	808.3	.0	6.0	100.0	881.7	.0	7.0	71.0	804.0	.0	4.0	100.0	985.0	.0	9.0	100.0	903.3	2.0
100.0	637.1	.0	5.0	100.0	630.0	.0	5.0	100.0	718.0	.0	5.0	100.0	750.0	.0	7.0	100.0	707.1	.0	5.0	100.0	796.0	.0

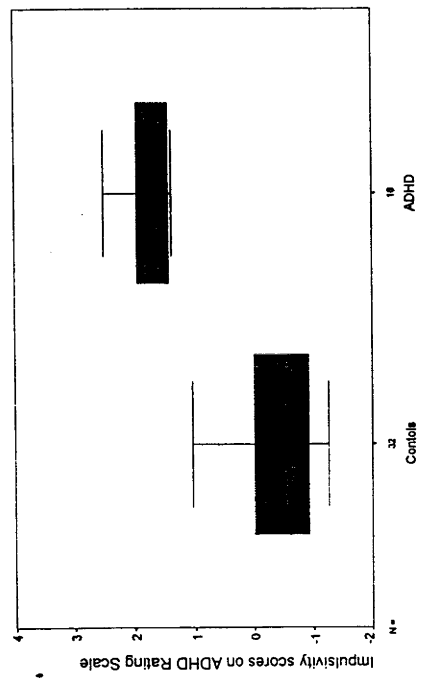
NTAR16	ORR16	MRT16	OMM16	NTAR17	CORR17	MRT17	COMM17	NTAR18	CORR18	MRT18	OMM18	NTAR19	ORR19	MRT19	OMM19	TAR20	CORR20	MRT20	OMM20	TAR21	CORR21	MRT21	COMM21	NTAR22
8.0	100.0	941.3	.0	3.0	33.0	650.0	8.0	6.0	100.0	846.7	6.0	6.0	100.0	816.7	9.0	9.0	100.0	786.7	12.0	5.0	80.0	870.0	20.0	6.0
7.0	100.0	660.0	2.0	5.0	100.0	926.0	6.0	2.0	100.0	900.0	.0	6.0	83.0	1004.0	9.0	5.0	40.0	1035.0	.0	6.0	66.0	832.5	2.0	6.0
5.0	100.0	950.0	2.0	5.0	80.0	542.5	2.0	8.0	87.0	928.6	7.0	6.0	100.0	780.0	4.0	8.0	62.0	1058.0	2.0	.0	60.0	871.7	7.0	7.0
4.0	100.0	750.0	.0	4.0	100.0	762.5	2.0	7.0	100.0	801.4	6.0	4.0	100.0	680.0	.0	6.0	100.0	945.0	.0	8.0	87.0	722.9	2.0	6.0
5.0	100.0	796.0	.0	6.0	83.0	852.0	2.0	4.0	75.0	853.3	.0	8.0	75.0	900.0	7.0	3.0	66.0	705.0	.0	8.0	75.0	735.0	2.0	4.0
6.0	100.0	990.0	2.0	6.0	83.0	730.0	6.0	.0	60.0	680.0	.0	6.0	33.0	735.0	2.0	6.0	33.0	790.0	2.0	6.0	33.0	820.0	4.0	7.0
7.0	100.0	840.0	.0	6.0	100.0	781.7	9.0	2.0	100.0	1065.0	.0	6.0	83.0	906.0	2.0	5.0	80.0	927.5	.0	3.0	33.0	1090.0	2.0	3.0
5.0	100.0	894.0	.0	6.0	83.0	852.0	2.0	6.0	66.0	940.0	.0	4.0	50.0	1065.0	4.0	5.0	40.0	1205.0	6.0	6.0	50.0	1166.7	2.0	7.0
6.0	.0	1500.0	.0	5.0	60.0	743.3	.0	3.0	66.0	705.0	2.0	8.0	87.0	611.4	.0	5.0	80.0	735.0	.0	3.0	66.0	625.0	.0	4.0
9.0	88.0	700.0	.0	3.0	100.0	706.7	2.0	5.0	60.0	763.3	2.0	7.0	71.0	820.0	.0	9.0	44.0	817.5	4.0	5.0	80.0	805.0	2.0	5.0
7.0	100.0	888.6	6.0	5.0	80.0	625.0	2.0	4.0	100.0	680.0	4.0	8.0	87.0	627.1	2.0	7.0	57.0	915.0	4.0	7.0	85.0	596.7	2.0	5.0
7.0	100.0	912.9	.0	3.0	100.0	1200.0	4.0	6.0	50.0	1146.7	4.0	5.0	60.0	1073.3	.0	3.0	33.0	1200.0	.0	8.0	50.0	967.5	4.0	3.0
4.0	100.0	1025.0	.0	5.0	60.0	670.0	2.0	6.0	100.0	1020.0	2.0	7.0	85.0	973.3	.0	6.0	33.0	1010.0	6.0	4.0	75.0	1056.7	4.0	7.0
6.0	100.0	708.3	.0	4.0	25.0	490.0	4.0	4.0	75.0	1090.0	2.0	7.0	85.0	918.3	2.0	5.0	100.0	840.0	2.0	7.0	100.0	800.0	.0	6.0
6.0	100.0	735.0	.0	5.0	100.0	808.0	2.0	6.0	100.0	798.3	2.0	6.0	66.0	817.5	2.0	4.0	100.0	942.5	2.0	6.0	100.0	743.3	.0	6.0
6.0	83.0	796.0	.0	7.0	28.0	735.0	4.0	7.0	28.0	760.0	.0	4.0	50.0	705.0	.0	3.0	66.0	595.0	.0	6.0	33.0	955.0	.0	7.0
6.0	100.0	826.7	.0	5.0	80.0	832.5	4.0	1.0	100.0	980.0	4.0	4.0	25.0	980.0	.0	6.0	83.0	850.0	2.0	7.0	71.0	706.0	9.0	3.0
8.0	75.0	973.3	.0	6.0	100.0	890.0	6.0	3.0	33.0	980.0	2.0	9.0	77.0	1100.0	.0	6.0	83.0	1126.0	.0	8.0	87.0	1092.9	9.0	6.0
4.0	100.0	970.0	.0	8.0	75.0	936.7	4.0	5.0	40.0	900.0	2.0	5.0	80.0	860.0	4.0	5.0	40.0	650.0	.0	4.0	25.0	820.0	.0	6.0
3.0	100.0	1056.7	4.0	.0	60.0	835.0	10.0	8.0	50.0	885.0	4.0	4.0	50.0	595.0	.0	6.0	.0	1500.0	4.0	5.0	60.0	943.3	2.0	6.0
9.0	100.0	610.0	.0	4.0	100.0	790.0	2.0	7.0	100.0	780.0	2.0	4.0	100.0	775.0	.0	6.0	100.0	698.3	6.0	7.0	100.0	565.7	4.0	6.0
5.0	100.0	686.0	2.0	6.0	100.0	826.7	.0	6.0	100.0	763.3	2.0	4.0	100.0	857.5	2.0	5.0	80.0	912.5	.0	9.0	77.0	824.3	7.0	6.0
6.0	100.0	908.3	.0	6.0	100.0	673.3	.0	7.0	85.0	661.7	2.0	5.0	80.0	707.5	4.0	.0	90.0	846.7	5.0	8.0	87.0	802.9	4.0	3.0
5.0	100.0	762.0	.0	5.0	100.0	598.0	2.0	4.0	100.0	777.5	4.0	5.0	100.0	994.0	.0	4.0	100.0	747.5	4.0	9.0	88.0	941.3	2.0	8.0
6.0	100.0	836.7	.0	7.0	71.0	762.0	.0	6.0	66.0	900.0	4.0	7.0	85.0	751.7	2.0	6.0	66.0	847.5	4.0	6.0	33.0	820.0	2.0	7.0
6.0	66.0	927.5	2.0	4.0	75.0	1056.7	4.0	6.0	33.0	1315.0	.0	5.0	80.0	1095.0	4.0	6.0	50.0	1240.0	6.0	5.0	40.0	1230.0	2.0	4.0
7.0	100.0	997.1	.0	7.0	85.0	725.0	4.0	.0	30.0	833.3	10.0	4.0	25.0	490.0	4.0	4.0	75.0	1036.7	.0	8.0	25.0	625.0	.0	5.0
5.0	80.0	817.5	.0	3.0	100.0	800.0	.0	6.0	83.0	698.0	6.0	7.0	85.0	835.0	4.0	4.0	50.0	735.0	2.0	5.0	60.0	1073.3	2.0	5.0
6.0	83.0	764.0	.0	5.0	40.0	900.0	2.0	5.0	60.0	1036.7	.0	5.0	20.0	1480.0	.0	6.0	50.0	930.0	2.0	8.0	75.0	873.3	2.0	7.0
5.0	100.0	696.0	6.0	5.0	100.0	674.0	.0	9.0	88.0	658.7	2.0	5.0	100.0	738.0	2.0	4.0	75.0	743.3	.0	6.0	83.0	828.0	.0	6.0
6.0	100.0	680.0	.0	6.0	100.0	926.7	2.0	5.0	60.0	816.7	2.0	7.0	85.0	953.3	4.0	7.0	71.0	962.0	.0	9.0	88.0	942.5	7.0	8.0
6.0	100.0	625.0	.0	4.0	100.0	637.5	4.0	6.0	100.0	671.7	.0	6.0	83.0	662.0	.0	5.0	100.0	764.0	2.0	5.0	100.0	628.0	2.0	6.0
4.0	75.0	760.0	.0	6.0	83.0	652.0	4.0	8.0	75.0	725.0	.0	8.0	75.0	963.3	.0	7.0	71.0	1016.0	2.0	5.0	80.0	1105.0	.0	7.0
8.0	100.0	657.5	.0	6.0	100.0	551.7	4.0	6.0	100.0	945.0	.0	6.0	100.0	743.3	.0	4.0	50.0	625.0	.0	9.0	100.0	798.9	.0	4.0
3.0	33.0	820.0	.0	7.0	85.0	818.3	4.0	7.0	57.0	830.0	4.0	7.0	42.0	966.7	.0	6.0	66.0	1105.0	4.0	4.0	50.0	875.0	.0	6.0
7.0	85.0	973.3	.0	4.0	75.0	893.3	2.0	3.0	66.0	845.0	2.0	5.0	100.0	828.0	.0	6.0	83.0	972.0	.0	3.0	100.0	796.7	.0	9.0
4.0	100.0	625.0	.0	5.0	100.0	552.0	4.0	1.0	100.0	600.0	2.0	4.0	100.0	747.5	.0	6.0	100.0	680.0	.0	7.0	100.0	590.0	.0	3.0
5.0	100.0	796.0	.0	7.0	100.0	708.6	9.0	6.0	100.0	586.7	4.0	4.0	100.0	597.5	.0	3.0	100.0	670.0	2.0	6.0	100.0	680.0	.0	4.0
4.0	100.0	762.5	.0	5.0	100.0	632.0	2.0	9.0	88.0	736.3	.0	5.0	100.0	664.0	2.0	7.0	71.0	816.0	2.0	6.0	100.0	935.0	.0	9.0
8.0	100.0	640.0	.0	3.0	33.0	980.0	4.0	9.0	66.0	825.0	2.0	6.0	83.0	994.0	.0	6.0	83.0	828.0	2.0	6.0	66.0	830.0	.0	3.0
3.0	100.0	763.3	4.0	7.0	85.0	733.3	.0	5.0	40.0	1065.0	.0	5.0	40.0	1040.0	2.0	7.0	57.0	775.0	.0	7.0	57.0	995.0	2.0	6.0
7.0	100.0	832.9	2.0	5.0	80.0	710.0	13.0	8.0	100.0	631.3	.0	5.0	100.0	784.0	.0	5.0	100.0	774.0	.0	6.0	100.0	991.7	.0	8.0
9.0	33.0	873.3	12.0	5.0	80.0	830.0	8.0	6.0	33.0	1065.0	6.0	6.0	33.0	790.0	4.0	5.0	20.0	980.0	6.0	7.0	57.0	900.0	11.0	5.0
8.0	100.0	1138.8	.0	.0	80.0	777.5	2.0	5.0	60.0	743.3	.0	4.0	75.0	1203.3	.0	6.0	66.0	952.5	.0	7.0	85.0	1018.3	.0	4.0
6.0	100.0	808.3	.0	6.0	33.0	710.0	6.0	6.0	33.0	600.0	6.0	5.0	80.0	860.0	26.0	6.0	16.0	160.0	9.0	8.0	62.0	456.0	28.0	8.0
5.0	100.0	850.0	.0	5.0	80.0	707.5	4.0	4.0	100.0	637.5	6.0	6.0	100.0	735.0	2.0	2.0	50.0	600.0	10.0	6.0	83.0	874.0	6.0	7.0
4.0	100.0	720.0	.0	3.0	100.0	893.3	.0	6.0	83.0	882.0	.0	5.0	100.0	1036.0	2.0	7.0	57.0	775.0	2.0	3.0	66.0	1145.0	2.0	6.0
4.0	100.0	612.5	.0	8.0	100.0	900.0	7.0	5.0	80.0	885.0	6.0	7.0	85.0	826.7	.0	8.0	100.0	976.2	.0	2.0	50.0	1150.0	2.0	6.0

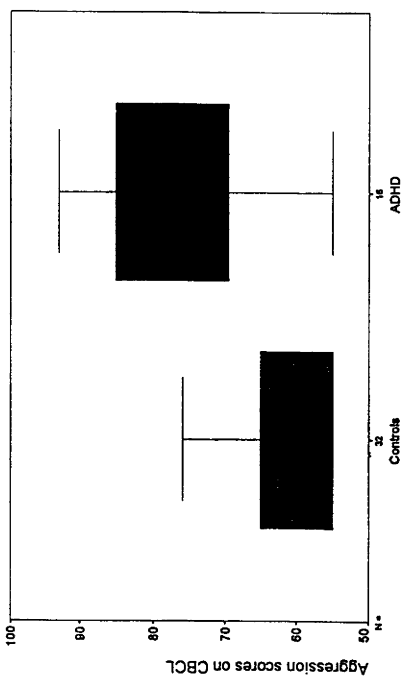
ORR22	MRT22	OMM22	NTAR23	CORR23	MRT23	OMM23	NTAR24	CORR24	MRT24	COMM24	TAR25	CORR25	MRT25	COMM25	NTAR26	CORR26	MRT26	COMM26	NTAR27	CORR27	MRT27	COMM27	NTAR28
66.0	982.5	9.0	8.0	62.0	654.0	26.0	3.0	100.0	783.3	29.0	6.0	83.0	574.0	18.0	7.0	85.0	810.0	32.0	4.0	75.0	856.7	10.0	5.0
66.0	792.5	6.0	6.0	66.0	1065.0	11.0	5.0	60.0	1036.7	2.0	.0	80.0	956.3	7.0	5.0	100.0	950.0	.0	9.0	88.0	1010.0	9.0	5.0
85.0	763.3	.0	8.0	100.0	968.8	7.0	7.0	71.0	772.0	2.0	9.0	88.0	983.8	7.0	9.0	77.0	872.9	.0	5.0	60.0	816.7	.0	4.0
83.0	730.0	.0	3.0	66.0	790.0	.0	8.0	75.0	881.7	.0	6.0	83.0	740.0	4.0	7.0	85.0	716.7	.0	8.0	50.0	817.5	.0	6.0
50.0	735.0	2.0	7.0	42.0	836.7	2.0	8.0	62.0	906.0	2.0	6.0	66.0	955.0	.0	6.0	83.0	1082.0	2.0	.0	90.0	988.9	2.0	7.0
28.0	985.0	.0	3.0	33.0	930.0	.0	7.0	.0	1500.0	.0	7.0	.0	1500.0	.0	6.0	.0	1500.0	.0	8.0	75.0	826.7	2.0	4.0
66.0	900.0	.0	6.0	66.0	1132.5	4.0	7.0	57.0	1135.0	6.0	8.0	87.0	1047.1	4.0	4.0	75.0	800.0	6.0	6.0	50.0	1220.0	2.0	7.0
14.0	1310.0	.0	3.0	66.0	1150.0	2.0	4.0	25.0	1090.0	.0	6.0	50.0	1296.7	9.0	6.0	66.0	1175.0	.0	6.0	50.0	910.0	4.0	7.0
25.0	1040.0	.0	5.0	60.0	596.7	.0	9.0	77.0	675.7	.0	9.0	77.0	684.3	4.0	6.0	100.0	635.0	2.0	8.0	75.0	623.3	.0	8.0
100.0	816.0	2.0	6.0	100.0	863.3	.0	4.0	50.0	900.0	2.0	5.0	100.0	874.0	2.0	4.0	75.0	873.3	.0	6.0	50.0	800.0	.0	2.0
40.0	955.0	4.0	5.0	60.0	763.3	6.0	8.0	50.0	625.0	2.0	7.0	100.0	787.1	6.0	7.0	85.0	773.3	.0	4.0	100.0	625.0	2.0	6.0
66.0	930.0	10.0	6.0	66.0	967.5	.0	5.0	20.0	650.0	4.0	5.0	100.0	904.0	4.0	3.0	33.0	1040.0	2.0	7.0	85.0	1148.3	2.0	5.0
57.0	940.0	6.0	8.0	62.0	960.0	9.0	8.0	50.0	1217.5	.0	7.0	57.0	1202.5	6.0	6.0	66.0	1135.0	4.0	.0	50.0	928.0	2.0	6.0
83.0	784.0	.0	8.0	87.0	1014.3	2.0	9.0	77.0	934.3	.0	5.0	80.0	1147.5	8.0	3.0	66.0	1090.0	.0	8.0	100.0	935.0	2.0	6.0
83.0	774.0	.0	3.0	100.0	653.3	.0	6.0	100.0	855.0	.0	8.0	100.0	1001.2	2.0	6.0	100.0	771.7	.0	7.0	85.0	808.3	4.0	7.0
28.0	710.0	2.0	3.0	.0	1500.0	2.0	6.0	50.0	796.7	.0	7.0	42.0	816.7	6.0	8.0	25.0	790.0	2.0	8.0	50.0	722.5	2.0	7.0
100.0	910.0	12.0	4.0	50.0	710.0	10.0	7.0	28.0	1230.0	9.0	6.0	66.0	695.0	6.0	7.0	28.0	845.0	11.0	4.0	50.0	650.0	2.0	5.0
50.0	1146.7	4.0	4.0	75.0	1293.3	2.0	8.0	37.0	1110.0	.0	7.0	42.0	1293.3	2.0	7.0	71.0	1168.0	2.0	7.0	42.0	1073.3	4.0	6.0
33.0	815.0	.0	8.0	75.0	790.0	7.0	6.0	50.0	710.0	.0	6.0	66.0	790.0	2.0	4.0	75.0	926.7	2.0	7.0	57.0	1120.0	2.0	8.0
50.0	1016.7	.0	8.0	62.0	960.0	11.0	5.0	100.0	950.0	20.0	5.0	60.0	1130.0	11.0	5.0	60.0	963.3	4.0	4.0	50.0	1095.0	2.0	5.0
100.0	751.7	.0	7.0	100.0	777.1	6.0	6.0	100.0	771.7	.0	7.0	100.0	762.9	.0	5.0	100.0	720.0	.0	5.0	100.0	872.0	4.0	7.0
50.0	743.3	.0	6.0	33.0	955.0	2.0	5.0	60.0	873.3	6.0	5.0	20.0	820.0	13.0	5.0	80.0	707.5	6.0	6.0	33.0	600.0	.0	4.0
100.0	853.3	2.0	6.0	83.0	918.0	9.0	6.0	83.0	828.0	4.0	8.0	87.0	754.3	2.0	7.0	85.0	801.7	4.0	7.0	100.0	897.1	4.0	7.0
87.0	848.6	2.0	7.0	85.0	898.3	6.0	5.0	100.0	916.0	.0	8.0	62.0	806.0	2.0	5.0	60.0	980.0	4.0	1.0	90.0	966.0	7.0	5.0
42.0	853.3	.0	5.0	60.0	983.3	.0	2.0	100.0	1175.0	.0	8.0	37.0	853.3	2.0	5.0	60.0	963.3	.0	6.0	50.0	783.3	.0	6.0
75.0	906.7	.0	3.0	66.0	815.0	2.0	6.0	16.0	760.0	6.0	4.0	100.0	710.0	4.0	4.0	50.0	625.0	2.0	7.0	57.0	830.0	2.0	6.0
20.0	1090.0	.0	3.0	.0	1500.0	.0	6.0	16.0	600.0	4.0	3.0	66.0	325.0	17.0	3.0	.0	1500.0	14.0	8.0	50.0	325.0	23.0	4.0
80.0	887.5	6.0	6.0	66.0	805.0	13.0	5.0	40.0	870.0	11.0	6.0	66.0	942.5	13.0	4.0	100.0	1052.5	.0	5.0	100.0	1058.0	4.0	6.0
28.0	1150.0	2.0	6.0	50.0	1366.7	.0	6.0	50.0	1056.7	.0	6.0	50.0	836.7	.0	6.0	16.0	1090.0	.0	5.0	20.0	1420.0	2.0	7.0
100.0	725.0	.0	4.0	100.0	765.0	2.0	8.0	75.0	753.3	.0	5.0	100.0	738.0	.0	4.0	100.0	762.5	.0	7.0	85.0	700.0	.0	3.0
87.0	967.1	2.0	7.0	85.0	955.0	.0	7.0	100.0	918.6	2.0	4.0	75.0	1020.0	2.0	5.0	80.0	912.5	.0	7.0	85.0	1075.0	2.0	8.0
100.0	718.3	.0	4.0	100.0	777.5	.0	4.0	75.0	893.3	.0	9.0	88.0	617.5	9.0	4.0	75.0	816.7	.0	1.0	.0	1500.0	.0	8.0
71.0	874.0	2.0	7.0	85.0	1048.3	.0	5.0	20.0	1480.0	.0	2.0	50.0	870.0	2.0	3.0	.0	1500.0	4.0	5.0	100.0	1180.0	2.0	9.0
75.0	910.0	.0	3.0	66.0	955.0	.0	6.0	83.0	950.0	.0	5.0	80.0	955.0	2.0	5.0	100.0	882.0	.0	7.0	57.0	902.5	2.0	3.0
83.0	926.0	.0	6.0	33.0	1010.0	.0	5.0	80.0	915.0	.0	6.0	66.0	1080.0	9.0	8.0	75.0	883.3	.0	6.0	33.0	955.0	4.0	5.0
77.0	855.7	.0	9.0	100.0	897.8	2.0	5.0	100.0	984.0	.0	4.0	100.0	997.5	.0	5.0	100.0	960.0	.0	6.0	50.0	943.3	2.0	4.0
100.0	763.3	.0	4.0	75.0	690.0	.0	7.0	100.0	740.0	.0	6.0	83.0	618.0	.0	7.0	100.0	770.0	2.0	4.0	100.0	787.5	.0	5.0
100.0	720.0	.0	7.0	100.0	722.9	4.0	6.0	100.0	680.0	.0	6.0	83.0	938.0	2.0	9.0	100.0	810.0	4.0	8.0	100.0	750.0	.0	5.0
88.0	948.8	2.0	7.0	100.0	817.1	.0	5.0	80.0	887.5	.0	8.0	87.0	1117.1	.0	7.0	71.0	806.0	.0	7.0	42.0	963.3	2.0	5.0
100.0	946.7	.0	7.0	42.0	1110.0	6.0	5.0	60.0	1020.0	.0	6.0	83.0	1070.0	.0	7.0	42.0	873.3	2.0	6.0	66.0	1077.5	4.0	6.0
16.0	760.0	2.0	6.0	33.0	1395.0	2.0	.0	.0	1500.0	.0	.0	.0	1500.0	.0	.0	.0	1500.0	.0	.0	.0	1500.0	.0	.0
100.0	838.7	.0	4.0	75.0	910.0	.0	9.0	77.0	817.1	.0	3.0	100.0	783.3	.0	7.0	100.0	897.1	.0	5.0	100.0	764.0	.0	8.0
60.0	963.3	2.0	7.0	71.0	908.0	9.0	8.0	75.0	908.3	2.0	4.0	25.0	1040.0	4.0	6.0	66.0	955.0	4.0	7.0	42.0	1163.3	9.0	7.0
25.0	1150.0	.0	3.0	33.0	1150.0	2.0	7.0	42.0	1053.3	.0	8.0	25.0	1010.0	.0	6.0	50.0	1293.3	.0	5.0	.0	1500.0	.0	7.0
25.0	680.0	.0	6.0	16.0	760.0	.0	6.0	16.0	600.0	.0	5.0	60.0	816.7	.0	7.0	28.0	790.0	.0	5.0	60.0	523.3	15.0	5.0
100.0	787.1	.0	5.0	60.0	726.7	2.0	5.0	.0	1500.0	.0	6.0	33.0	955.0	2.0	5.0	100.0	796.0	2.0	7.0	14.0	930.0	4.0	8.0
83.0	860.0	.0	7.0	100.0	1154.3	.0	5.0	60.0	1040.0	.0	8.0	87.0	1012.9	2.0	4.0	75.0	816.7	.0	5.0	80.0	900.0	.0	7.0
100.0	955.0	.0	7.0	85.0	1000.0	6.0	3.0	33.0	710.0	.0	4.0	100.0	915.0	.0	5.0	80.0	845.0	2.0	5.0	40.0	790.0	4.0	5.0

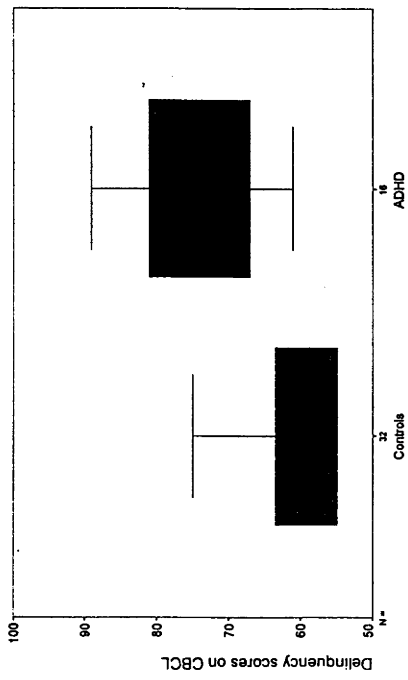
CORR28	MRT28	OMM28	NTAR29	CORR29	MRT29	COMM29	NTAR30	CORR30	MRT30	COMM30	NTAR31	CORR31	MRT31	COMM31	NTAR32	CORR32	MRT32	COMM32
80.0	887.5	15.0	6.0	66.0	830.0	#NULL!	5.0	80.0	970.0	4.0	6.0	83.0	894.0	4.0	7.0	42.0	1126.7	9.0
80.0	875.0	8.0	6.0	100.0	1028.3	2.0	6.0	100.0	853.3	2.0	3.0	100.0	890.0	.0	5.0	100.0	796.0	4.0
100.0	750.0	.0	6.0	50.0	910.0	6.0	6.0	83.0	1016.0	2.0	4.0	50.0	875.0	.0	8.0	87.0	770.0	4.0
66.0	735.0	2.0	3.0	66.0	790.0	.0	4.0	25.0	930.0	4.0	7.0	57.0	585.0	.0	5.0	20.0	820.0	.0
42.0	873.3	4.0	3.0	66.0	1150.0	4.0	4.0	100.0	885.0	2.0	7.0	100.0	951.4	6.0	4.0	100.0	927.5	4.0
50.0	925.0	2.0	4.0	25.0	650.0	.0	4.0	50.0	955.0	2.0	7.0	28.0	1090.0	.0	5.0	60.0	833.3	.0
85.0	1063.3	6.0	4.0	100.0	915.0	6.0	8.0	100.0	927.5	.0	6.0	33.0	1175.0	.0	6.0	100.0	726.7	.0
57.0	1297.5	.0	4.0	50.0	955.0	2.0	7.0	28.0	1120.0	.0	6.0	33.0	1175.0	.0	5.0	60.0	1016.7	2.0
50.0	640.0	.0	7.0	71.0	620.0	4.0	5.0	40.0	735.0	.0	4.0	50.0	625.0	.0	4.0	75.0	670.0	.0
50.0	1090.0	2.0	5.0	60.0	1093.3	4.0	4.0	75.0	983.3	.0	7.0	14.0	650.0	4.0	6.0	50.0	910.0	.0
100.0	725.0	6.0	8.0	100.0	707.5	7.0	8.0	75.0	901.7	.0	5.0	80.0	637.5	4.0	3.0	100.0	723.3	2.0
60.0	523.3	6.0	8.0	62.0	1070.0	.0	5.0	60.0	1333.3	.0	7.0	28.0	1285.0	2.0	7.0	42.0	943.3	.0
50.0	1093.3	.0	9.0	11.0	870.0	9.0	5.0	40.0	1230.0	2.0	8.0	37.0	1240.0	7.0	4.0	25.0	1150.0	.0
83.0	1048.0	2.0	3.0	100.0	1056.7	.0	6.0	100.0	900.0	2.0	6.0	83.0	1026.0	.0	4.0	75.0	983.3	.0
85.0	706.7	2.0	4.0	75.0	800.0	2.0	4.0	75.0	706.7	2.0	7.0	100.0	738.6	4.0	9.0	77.0	808.6	2.0
28.0	765.0	.0	6.0	16.0	540.0	.0	5.0	100.0	806.0	2.0	7.0	14.0	1530.0	.0	7.0	14.0	650.0	4.0
60.0	710.0	11.0	1.0	100.0	1040.0	6.0	5.0	20.0	820.0	4.0	4.0	50.0	820.0	2.0	5.0	60.0	836.7	4.0
50.0	1093.3	.0	4.0	25.0	1040.0	.0	4.0	.0	1500.0	4.0	6.0	.0	1500.0	.0	3.0	66.0	1095.0	4.0
75.0	918.3	4.0	8.0	75.0	1000.0	.0	5.0	40.0	1095.0	.0	6.0	50.0	890.0	.0	5.0	60.0	1056.7	4.0
20.0	1310.0	2.0	8.0	62.0	852.0	9.0	8.0	37.0	1183.3	4.0	6.0	33.0	1315.0	2.0	5.0	.0	1500.0	2.0
100.0	708.6	4.0	4.0	100.0	640.0	.0	8.0	100.0	611.3	2.0	8.0	100.0	605.0	4.0	3.0	100.0	653.3	4.0
50.0	955.0	6.0	6.0	83.0	786.0	2.0	5.0	60.0	836.7	2.0	9.0	66.0	706.7	2.0	3.0	66.0	925.0	4.0
71.0	706.0	2.0	4.0	50.0	1150.0	.0	6.0	83.0	808.0	6.0	4.0	75.0	926.7	2.0	6.0	66.0	857.5	2.0
40.0	930.0	.0	6.0	66.0	1080.0	2.0	8.0	75.0	836.7	.0	7.0	71.0	774.0	.0	3.0	33.0	1480.0	8.0
33.0	900.0	.0	6.0	33.0	955.0	4.0	4.0	25.0	760.0	2.0	8.0	25.0	790.0	.0	4.0	50.0	875.0	.0
33.0	845.0	4.0	4.0	.0	1500.0	.0	3.0	.0	1500.0	.0	6.0	16.0	870.0	.0	8.0	25.0	625.0	.0
50.0	1065.0	2.0	4.0	.0	1500.0	8.0	6.0	16.0	870.0	2.0	6.0	.0	1500.0	.0	8.0	25.0	325.0	11.0
83.0	958.0	2.0	5.0	80.0	1007.5	.0	7.0	85.0	861.7	.0	5.0	60.0	910.0	6.0	8.0	50.0	832.5	.0
28.0	845.0	2.0	4.0	50.0	1090.0	2.0	7.0	42.0	890.0	2.0	5.0	40.0	930.0	2.0	4.0	50.0	680.0	4.0
66.0	815.0	.0	8.0	75.0	818.3	.0	6.0	100.0	826.7	.0	7.0	85.0	661.7	2.0	6.0	100.0	798.3	.0
75.0	1120.0	7.0	6.0	50.0	966.7	2.0	6.0	100.0	910.0	2.0	7.0	100.0	981.4	.0	2.0	100.0	765.0	4.0
100.0	672.5	2.0	5.0	100.0	686.0	.0	5.0	80.0	652.5	.0	4.0	75.0	616.7	.0	4.0	100.0	695.0	2.0
66.0	1081.7	2.0	9.0	44.0	915.0	.0	5.0	80.0	942.5	4.0	5.0	60.0	946.7	.0	.0	40.0	902.5	.0
100.0	1036.7	.0	5.0	60.0	1203.3	.0	4.0	50.0	955.0	.0	8.0	25.0	1175.0	.0	8.0	100.0	996.3	.0
60.0	890.0	2.0	7.0	57.0	612.5	2.0	4.0	100.0	832.5	2.0	5.0	80.0	957.5	4.0	4.0	25.0	1530.0	.0
50.0	955.0	2.0	6.0	83.0	774.0	.0	5.0	80.0	1010.0	.0	6.0	83.0	1104.0	2.0	5.0	80.0	900.0	.0
100.0	662.0	2.0	1.0	100.0	490.0	.0	5.0	100.0	718.0	.0	4.0	100.0	830.0	4.0	5.0	80.0	762.5	2.0
100.0	872.0	2.0	7.0	100.0	785.7	2.0	7.0	100.0	825.7	6.0	4.0	100.0	1010.0	2.0	4.0	100.0	775.0	.0
100.0	840.0	.0	6.0	100.0	853.3	.0	6.0	83.0	906.0	2.0	8.0	62.0	774.0	4.0	4.0	100.0	777.5	4.0
66.0	1092.5	.0	8.0	75.0	1110.0	2.0	6.0	66.0	942.5	.0	5.0	80.0	1065.0	.0	5.0	40.0	1120.0	2.0
.0	1500.0	.0	.0	.0	1500.0	.0	.0	.0	1500.0	.0	.0	.0	1500.0	.0	.0	.0	1500.0	.0
100.0	797.5	.0	7.0	85.0	808.3	.0	4.0	100.0	802.5	.0	5.0	100.0	882.0	.0	6.0	83.0	850.0	2.0
71.0	1060.0	4.0	6.0	50.0	1276.7	2.0	6.0	16.0	870.0	.0	3.0	33.0	1090.0	2.0	6.0	16.0	820.0	4.0
14.0	1420.0	.0	5.0	20.0	1150.0	.0	5.0	.0	1500.0	.0	4.0	25.0	1090.0	2.0	8.0	50.0	1132.5	2.0
20.0	930.0	.0	5.0	60.0	616.7	15.0	4.0	.0	1500.0	.0	5.0	40.0	600.0	8.0	6.0	16.0	1150.0	.0
62.0	992.0	7.0	1.0	.0	1500.0	.0	5.0	40.0	925.0	2.0	6.0	16.0	1480.0	4.0	7.0	57.0	982.5	2.0
100.0	864.3	.0	7.0	71.0	1004.0	.0	5.0	60.0	926.7	2.0	5.0	80.0	970.0	4.0	9.0	66.0	1045.0	4.0
100.0	850.0	.0	5.0	80.0	995.0	2.0	7.0	42.0	910.0	2.0	5.0	80.0	790.0	.0	7.0	85.0	826.7	.0

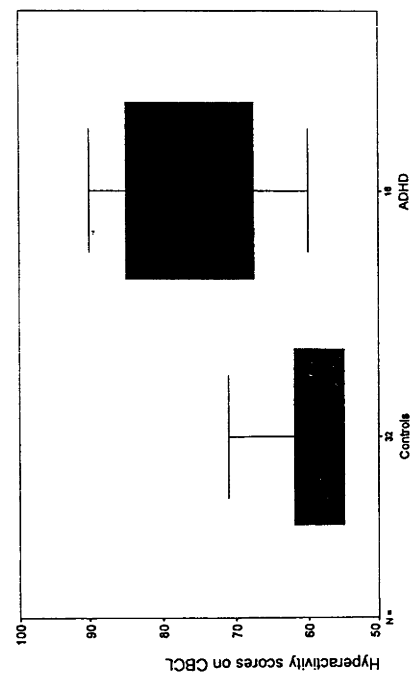
APPENDIX H: Figure 3.1 Box plots for behavioural measures











APPENDIX I: Table 3.3 to Table 3.5

Tables 3.3 Repeated ANOVA for Reaction Time using AGE and IQ as covariates

	Ss	df	ms	F	sig
Regression	3871599.01	2	1935799.5	6.48	.003
Group	60086.63	1	60086.63	0.20	.656
Error 1	13134314.90	44	98507.16		
Task	3785240.18	1	3785240.2	30.47	.000*
Group*task	1423.00	1	1423.00	0.01	.915
Error 2	5710195.65	46	124134.69		
Time	2159307.61	15	143953.84	6.89	.000*
Group*time	340439.03	15	22659.94	1.09	.365
Error 3	14418155.12	690	20895.88		
Task*time	232078.27	15	15471.88	0.73	.753
Gp*tm*task	252900.81	15	16860.05	0.80	.681
Error4	14580042.25	690	21130.50		

p=<.05

Table 3.3.1 Correlations for AGE and IQ with Mean Reaction Time

Covariate	B	Beta	St.Error	t	sig
AGE	-2.82305	-.42314	0.884	-3.192	0.003*
IQ	-1.95741	-.24040	1.074	-1.823	0.075

*p<.01

Tables 3.4 Repeated ANOVA for Transformed % Correct Hits using AGE and IQ as covariates

	ss	df	ms	F	sig
Regression	100568.60	2	50284.30	13.21	.000**
Group	1.25	1	1.25	0.00	.986
Error 1	167425.58	44	3805.13		
Task	205670.08	1	205670.08	86.38	.000**
Group*task	3951.26	1	3951.26	1.66	.204
Error 2	109527.29	46	2381.03		
Time	24987.85	15	1665.86	4.99	.000**
Group*time	6606.67	15	440.44	1.32	.184
Error 3	230462.63	690	334.00		
Task *time	10261.74	15	684.12	2.39	.002*
Gp* tm*task	3103.19	15	206.88	0.72	.762
Error4	197302.65	690	285.95		

*p<.01, **p<.001.

Table 3.4.1 Correlations for AGE and IQ (covariates) with %Correct hits

Covariate	B	Beta	St.Error	t	sig
AGE	.48452	.58087	.100	4.853	.000*
IQ	.23462	.23047	.121	1.935	.059

*p<.001

Tables 3.5 Repeated ANOVA for Transformed % Commission Errors using AGE and IQ as covariates

	ss	df	ms	F	sig
Regression	647.03	2	323.51	5.99	.005**
Group	111.38	1	111.38	2.06	.158
Error 1	2376.96	44	54.02		
Task	1236.52	1	1236.52	35.20	.000***
Group*task	36.53	1	36.53	1.04	.313
Error 2	1616.09	46	35.13		
Time	277.39	15	18.49	2.38	.002**
Group*time	199.94	15	13.33	1.72	.043*
Error 3	554.57	720	7.70		
Task *time	195.03	15	13.00	1.74	.039*
Gp*tm*task	83.19	15	5.55	0.74	.740
Error4	5143.21	690	7.45		

*p<.05, **p<.01, ***p<.001.

Table 3.5.1 Correlations for AGE and IQ for %Commission Error

Covariate	B	Beta	St.Error	t	sig
AGE	-.02974	-.32670	.012	-2.500	.016*
IQ	-.03631	-.32686	.014	-2.514	.016*

*p<.05